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HOW TO BOOST U.S. EXPORTS

Bernard Ziegler
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General Motors is on a journey to a far-off place just around the corner, the 21st Century. With the help of its thousands of scientists, designers and engineers, GM is embarking on an odyssey into the unknown. Roads paved with scientific and technological wonders that might seem like science fiction. But at GM, they're reality. Now. Lasers that probe body structure as no man's eyes ever could. Electronic navigation systems that tell you where you are and how to get where you're going. But the road doesn't stop there. The 21st Century lies dead ahead. GM is leading the way there by adding new dimensions of electronic wizardry and computer expertise to its vast worldwide resources. Today's GM is evolving into a GM the future will demand. Bolder. Daring. More responsive. Speaking a new language. Venturing in new directions.

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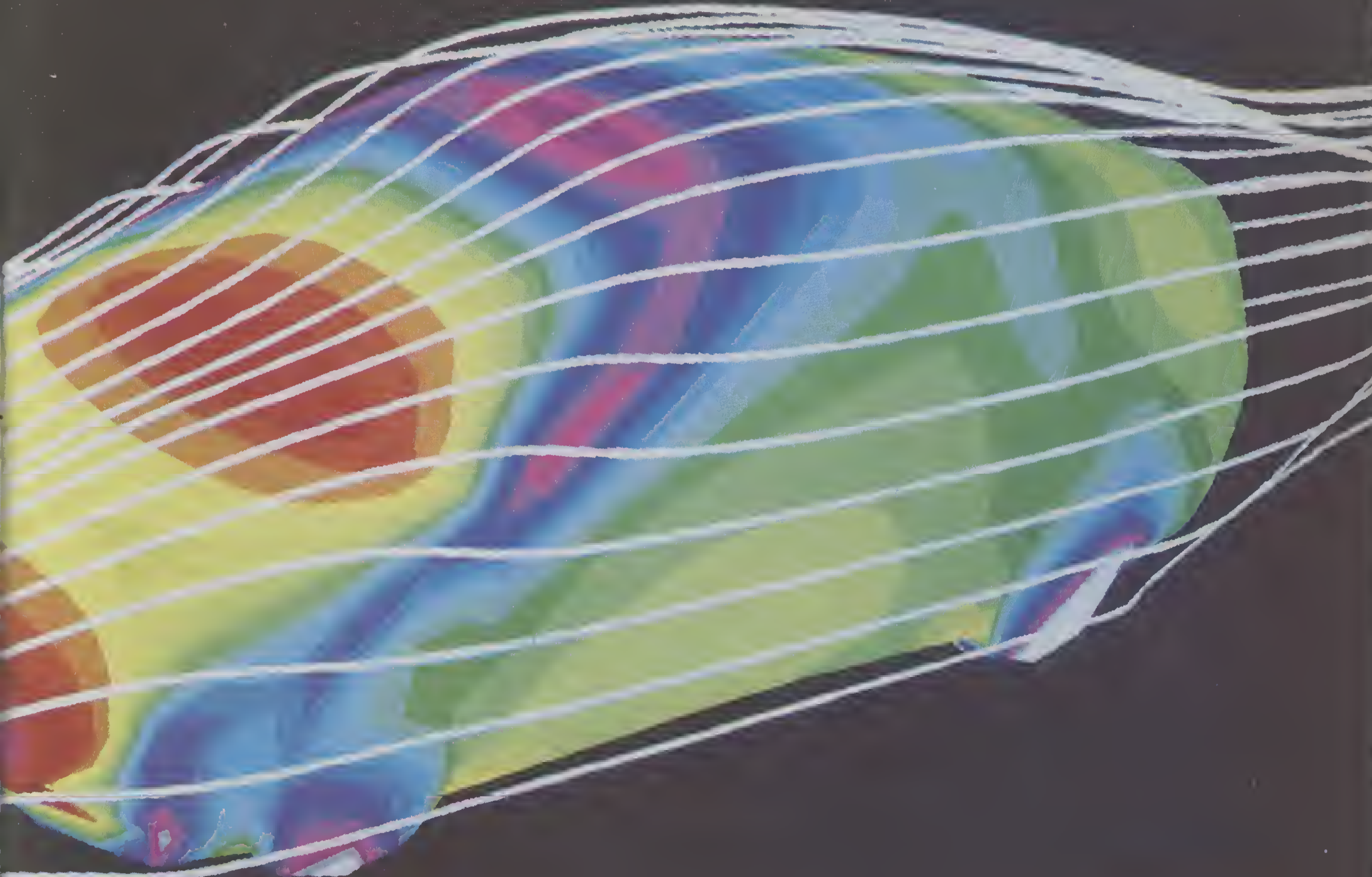

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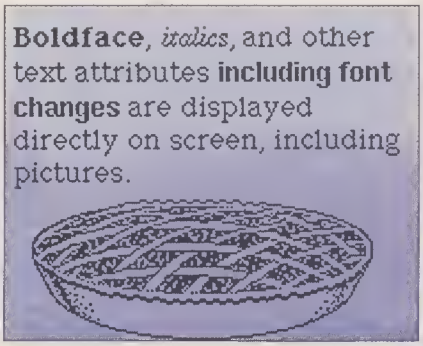

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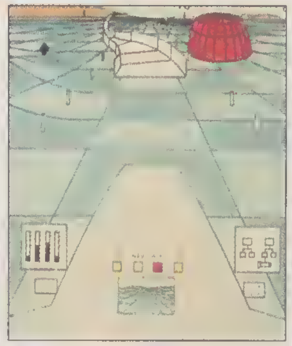

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FEATURES

DEPARTMENTS

Cover Bernard Ziegler, Airbus Industrie's engineering VP, mans the electronic cockpit of the new Airbus 320 airliner. Photo by Zigy Kaluzny/Gamma Liaison.

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OPINION

Help wanted: technology adviser for the President

The President of the United States needs a technology adviser. A science adviser alone is not adequate. As the United States gradually loses its leadership position in one technology after another, the outlook for the U.S. economy gets bleaker. Advice on particle accelerators, cancer research, and space projects may be useful, but it won't help the President tackle this problem.

The position of a full-time science adviser was created in the late '50s, after the USSR launched its first Sputnik. The American public, accustomed to thinking of the United States as the world's leader in science and technology, was shocked by the Russians' accomplishment. The purpose of the new adviser was to help keep the President informed of the latest scientific developments and to provide guidance on priorities as the nation boosted its R&D expenditures.

But today, as the United States continues to win more Nobel Prizes for science than any other nation while its global share in many technology markets dwindles or even vanishes, it is clear that the President has a much greater need for someone who understands microchip, biotechnology, and computer technology and markets than for someone versed in the needs of theoretical physicists.

Some economists preach that it is best to lose our "sunset" manufacturing industries—such as shoes, textiles, and steel—if other nations can produce such goods cheaper. With better use of advanced technologies, however, many of those industries might remain alive and competitive in the U.S.

The economic threat extends to the "sunrise" industries as well. The cost of losing such growth technologies as optoelectronics, ceramics, genetic engineering, and integrated circuits would be tremendous. These will provide rapidly expanding opportunities to serve tomorrow's giant global markets.

Other nations are not waiting for the United States. They are already using sophisticated technologies as part of well-coordinated national policies to advance a wide range of industries. Consequently, the loss of many jobs in the U.S. stems not from automation, but rather from the lack of it.

The President could benefit from a technology adviser with broad experience in both engineering and management. The adviser shouldn't be a superlobbyist for a particular industry, but a good communicator who would stay in touch with those on the firing line in a broad spectrum of technology businesses.

That kind of savvy just can't be expected from a scientist; the research laboratory is a far cry from the marketplace. And unless changes are made, and made quickly, it is in the global marketplace that the U.S. is heading for deep trouble.

Robert Haavind

Robert Haavind

PAUL MOCK

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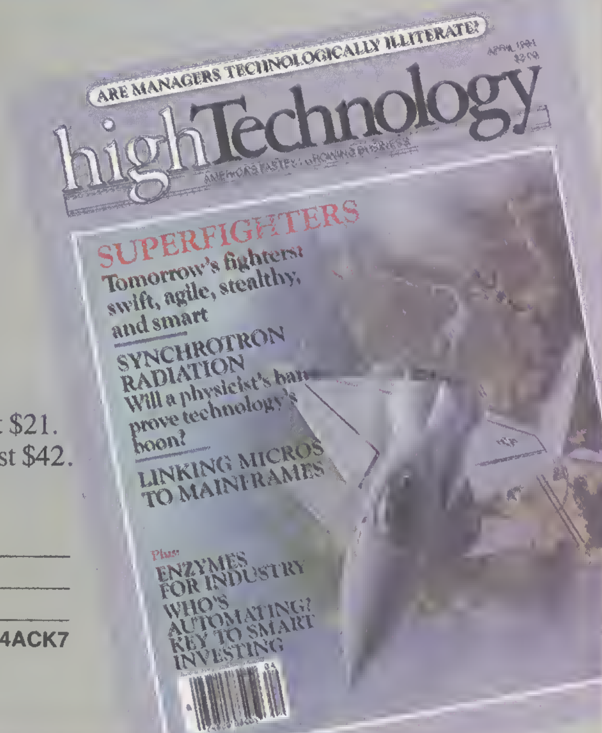

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(Sept., p. 57).

Eric M. Sakaguchi
Honolulu, Hi.

Editor's note: Lawrence K. Edwards, chief of advanced transportation at NASA's Office of Space Flight (Washington, D.C.), responds to Mr. Sakaguchi's letter as follows:

From a distance, jet turbine blades may appear flat. However, a closer inspection will reveal that they have a precisely machined curvature (see photo).

For example, the fuel pump drive unit in NASA's OTV will employ curved blades. Fuel will enter from the combustion chamber, be

PHOTOS COURTESY OF G.E.

Mr. Peters is coauthor of In Search of Excellence.

Keeping membranes straight

In "A renaissance in recycling" (Oct., p. 32), you have erroneously identified the Membrane Gas Separation System (at Northwest Natural Gas Co.'s landfill gas-recovery facility in Oregon City, Ore.) as Monsanto's Prism separator. This system, in use since the summer of 1984, is actually a Separex Membrane Gas Separation System utilizing Separex Corp.'s spiral-wound cellulose ace-

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Peter Martin
Titusville, Fla.

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LETTERS

The key to communicating

"Computers and communications: toward peace and prosperity" (Aug., p. 10) suggests that the development of a global information structure will contribute to world peace. But to focus on the conduit of communication while overlooking the content is akin to searching for one's keys under the street lamp simply because it's light there.

The fact that more technology will be available does not mean it will be equally accessible to everyone. Nor does technology necessarily lead to more or better communication: In fact, some research already shows that managers look for ways to limit the information they receive, not increase it.

In addition, the suggestion that automatic translators will allow strangers to talk to each other ignores the question of who is controlling the translations (no translation is a-cultural) and the problem of conflicting interpretive contexts. Even conversations between subcultures within any one country are problematic; pure language differences are not the primary problem.

I am not just saying that we need more than technology to attain world peace—that's apparent. I'm saying that there is nothing about technology itself that will lead us to that goal, and that to focus our efforts on technology rather than on the development of a motivated, conscious, critically thinking population is to fool ourselves.

Susan E. Koch
Morristown, N.J.

Editor's note: The writer is a staff member of Bell Communications Research. The views expressed are her own.

The curve of the blade

I would like to know whether you think foiled blades, as opposed to the flat blades used in jet turbines, would increase the RPMs of the fuel pumps used in the orbital transfer vehicles (OTVs) mentioned in the article "Paving the way for space tugs" (Sept., p. 57).

Eric M. Sakaguchi
Honolulu, Hi.

Editor's note: Lawrence K. Edwards, chief of advanced transportation at NASA's Office of Space Flight (Washington, D.C.), responds to Mr. Sakaguchi's letter as follows:

From a distance, jet turbine blades may appear flat. However, a closer inspection will reveal that they have a precisely machined curvature (see photo).

For example, the fuel pump drive unit in NASA's OTV will employ curved blades. Fuel will enter from the combustion chamber, be curved to the correct angle for impingement on the moving blade, then exit from the moving blades in the axial direction.

This airfoil shape for turbine blades has been used in industrial and jet turbine engines for a long time to promote smooth, unseparated flow of fuel through the fixed and the moving blades, thereby minimizing separation loss and increasing output.

PHOTOS COURTESY OF G E

Putting customers first

Hats off for your Opinion piece "How to meet the foreign challenge" (Oct., p. 4).

High tech industry should hear about the needs of their customers much, much more often. Hope you repeat the message regularly.

Thomas J. Peters
Palo Alto, Cal.

Mr. Peters is coauthor of In Search of Excellence.

Keeping membranes straight

In "A renaissance in recycling" (Oct., p. 32), you have erroneously identified the Membrane Gas Separation System (at Northwest Natural Gas Co.'s landfill gas-recovery facility in Oregon City, Ore.) as Monsanto's Prism separator. This system, in use since the summer of 1984, is actually a Separex Membrane Gas Separation System utilizing Separex Corp.'s spiral-wound cellulose acetate membrane.

The Separex system has the benefit of simultaneously recovering and dehydrating the fuel gas, thus avoiding a costly secondary operation. The system also separates carbon dioxide from the biogas, producing a "pipeline quality" fuel gas.

Michael G. Wyles
Senior Vice-President
Perry Gas Companies
Odessa, Tex.

First with CMOS

I read with interest the article "Digital signal processors" (Oct., p. 25). However, I was surprised to see that although HIGH TECHNOLOGY is headquartered in Boston, there was no mention of Norwood-based Analog Devices' role in DSP.

Analog Devices introduced the first CMOS DSP products in November 1982, and all of our DSP products have been built on our proprietary CMOS process. Yet no mention was made of these facts when the advantages of CMOS-built chips were touted. We also pioneered the first CMOS data converters back in the early '70s, and today we dominate that market.

Analog plans on being a dominant force in the signal processing marketplace, and digital signal processing will play an important part in our long-term strategic plans.

Al Haun
Analog Devices
Norwood, Mass.

Editor's note: The article focused on the trend toward the manufacture of fully integrated DSP chips rather than discrete-function chips—such as those produced by Analog Devices—that can be combined to create board-level DSP devices.

Misidentified flying objects

I would like to call to your attention the illustration on p. 42 for the story "Supersonic jump jets" (Sept., p. 38). The titles of the first and second illustrations should be reversed: The engine on the first has an ejector-type nozzle, while the second illustration shows the vectored thrust plus plenum-chamber burning arrangement as used on the McDonnell Douglas 279-3.

Peter Martin
Titusville, Fla.

We welcome comments from our readers. Please address letters to Editor, High Technology, 38 Commercial Wharf, Boston, MA 02110.

If The Old Ideas About
We Wouldn't Need So Many

Look past the chained gates of any closed factory.

You'll see that, long before the gears stopped turning, the ideas that drove them stopped working.

And all too often, the decision makers in business as well as in government decided to ignore the revolution in technology.

The people of one state, however, decided to lead that revolution.

Years before the rising tide of education's critics, North Carolina dedicated its public and private resources to excellence and purpose in education.

The goal was to help our people and our businesses advance with technology.

The results are the envy not just of other states, but of other countries.

We're the tenth-largest state, but we have the fifth-largest university system.

And, amazingly, our community colleges enroll one out of seven North Carolina adults.

So employers here almost never have trouble finding skilled labor and management talent.

Our grade-and high-

UPDATE

New trade route to China: via Hong Kong

In an effort to remove obstacles to foreign trade, many Chinese companies—both government-run and private—are opening branch offices in Hong Kong. The colony's modern amenities and preeminence as a banking center allow overseas firms to carry out financial transactions, transport and house their representatives, and maintain contact through telephone and telex much more easily than in the People's Republic.

Not only are new offices opening up, but Chinese businesses already established in Hong Kong—including the Bank of China and several textile trading companies—are branching out into new areas, such as high tech imports and joint ventures. This increase in Hong Kong–based trade may have been spurred partly by Britain's recent agreement to reunite Hong Kong with China in 1997, says John Callebaut, an official of the National Council for U.S.-China Trade (Washington, D.C.). It may also stem from a growing recognition on the part of China that its relatively primitive telephone and transportation systems can raise barriers to foreign firms.

In any case, says Callebaut, opportunities for high tech firms to do business with China are on the rise—not primarily in consumer goods, as many Western companies believe, but in equipment to update the country's infrastructure, in areas such as telecommunications, transportation, and development of energy resources. "China has a lot of modernization left to do," says Callebaut, and it has earmarked its foreign currency for the advanced equipment it needs to do the task.

Showcase car sets the pace for Detroit

A recently introduced "concept" car, the two-seater Buick Wildcat, may provide a glimpse of what lies ahead for U.S. production cars. The most readily apparent innovation is its body—a sleek, lightweight carbon-fiber shell with an integrated frame rather than a separate chassis. Equally advanced is the car's instrumentation. An aircraft-style "heads-up" speedometer, consisting of a transparent screen that reflects information from a dashboard display, allows drivers to keep their eyes on the road while monitoring speed. Other important readouts are mounted in the stationary hub of the steering wheel. In addition, a video display can be switched to show engine data, g forces on the front, rear, and sides of the car, tire slippage during turns, and horsepower and torque.

The Wildcat's 24-valve engine (a first for a GM car) develops 230 horsepower at 6000 rpm. With all that power, Buick's engineers have added full-time four-wheel drive, a feature not found in other U.S. cars; a torque divider transmits two-thirds of the power to the rear wheels and one-third to the front.

Although chances are good that many of these innovations will soon find their way into the marketplace, Buick isn't planning to implement them all at once. Therefore, the Wildcat may be seen at auto shows and motorsports events, but don't expect to spot it on the road.

Buick's Wildcat "concept" car.

Defense program funds medical laser research

Proponents of the Stategic Defense Initiative (SDI) often cite the prospect of civilian applications for "Star Wars" technologies. In a move that will likely produce such spinoffs, Congress has directed the Pentagon's SDI Organization to begin funding several institutions to study medical uses for free-electron lasers (FELs). These lasers, which generate powerful beams of light by channeling electrons through a specially shaped magnetic field, are also a leading candidate for ground-based missile defense.

Invented in the '70s, the FEL has a unique combination of high intensity and "tunability" (that is, its wavelength can be continuously tuned by adjusting the energy of the electrons). Such a laser would make it much easier to study the effectiveness of different wavelengths for removing diseased tissue. Other high-power lasers are restricted to a few discrete wavelengths; dye lasers are widely tunable but comparatively dim.

The SDI budget will probably include a total of $50–60 million for the medical studies over the next five years, according to Dwight Duston, assistant director for innovative science and technology. Preliminary contracts have gone to Stanford U., Mass. General Hospital (Boston), and the Uniformed Services University for the Health Sciences (Bethesda, Md.)—a med school that produces military doctors.

Improved alloys take the heat

Alloys made with silicon nitride may soon go into jet engines, gas turbines, boilers, oil refineries, and many other environments that present the double whammy of high temperature and severe corrosion. The alloys, developed by Penn. State Univ. metallurgist George Simkovich, are believed to withstand harsh conditions better than today's "super alloys" made with chromium, and should eventually cost less. Another plus: Unlike chromium, which the U.S. imports mostly from politically unstable nations such as South Africa, silicon nitride consists of readily available materials.

Large amounts of chromium, sometimes as much as 30% by weight, are added to conventional alloys to retard oxidation and other corrosion that sets in above 600° C. American firms now produce more than 30,000 tons of high-temperature chromium alloys annually. But the relatively pure form of chromium used in super alloys is expensive—up to $3 a pound. Simkovich replaces much of the chromium with silicon nitride powder. In lab tests, he says, the new alloys not only resist corrosion much better but also suffer virtually none of the "spalling," or shedding of scales, that plagues chromium alloys during repeated heating and cooling. Silicon nitride is currently more expensive than chromium: about $5 a pound. However, less of the material is needed, and in any case, says Simkovich, the price would drop as demand increased.

Simkovich is testing the alloys' mechanical properties. If they match those of chromium alloys, the new materials could be used structurally. If not, they should still prove valuable as a coating and for use where strength is not critical. Test results should be in by midyear, which is when patent approval is expected.

U.S. firms plan auto ceramics venture

The first joint venture between a major U.S. supplier of engine components and a leading producer of advanced ceramics could speed development of automobile engines with markedly improved fuel efficiency and performance. Norton Co. (Worcester, Mass.) and TRW (Cleveland) have made what the companies call a "long-term commitment" to developing and marketing a variety of heat-resistant, durable ceramic components for use in gasoline, diesel, and gas turbine engines.

The new organization, Norton/TRW Ceramics, hopes to begin spinning off commercial manufacturing operations by the early 1990s. The first components produced will likely be fairly simple valve-train parts such as wear pads for tappets and push rods, says Norton VP Richard Alliegro. Farther down the road: valves and turbocharger rotors. The new firm's researchers—some 30 initially, with significant growth planned—will focus primarily on silicon nitride and partially stabilized zirconia.

The U.S. auto industry has long flirted with ceramic engine research. But the pulse is quickening—partly because of Japanese advances in ceramics research—as companies try to squeeze maximum performance out of smaller engines. Business Communications (Stamford, Conn.) estimates that by the year 2000 the market for ceramic engine components could exceed $2 billion annually.


MONSANTO

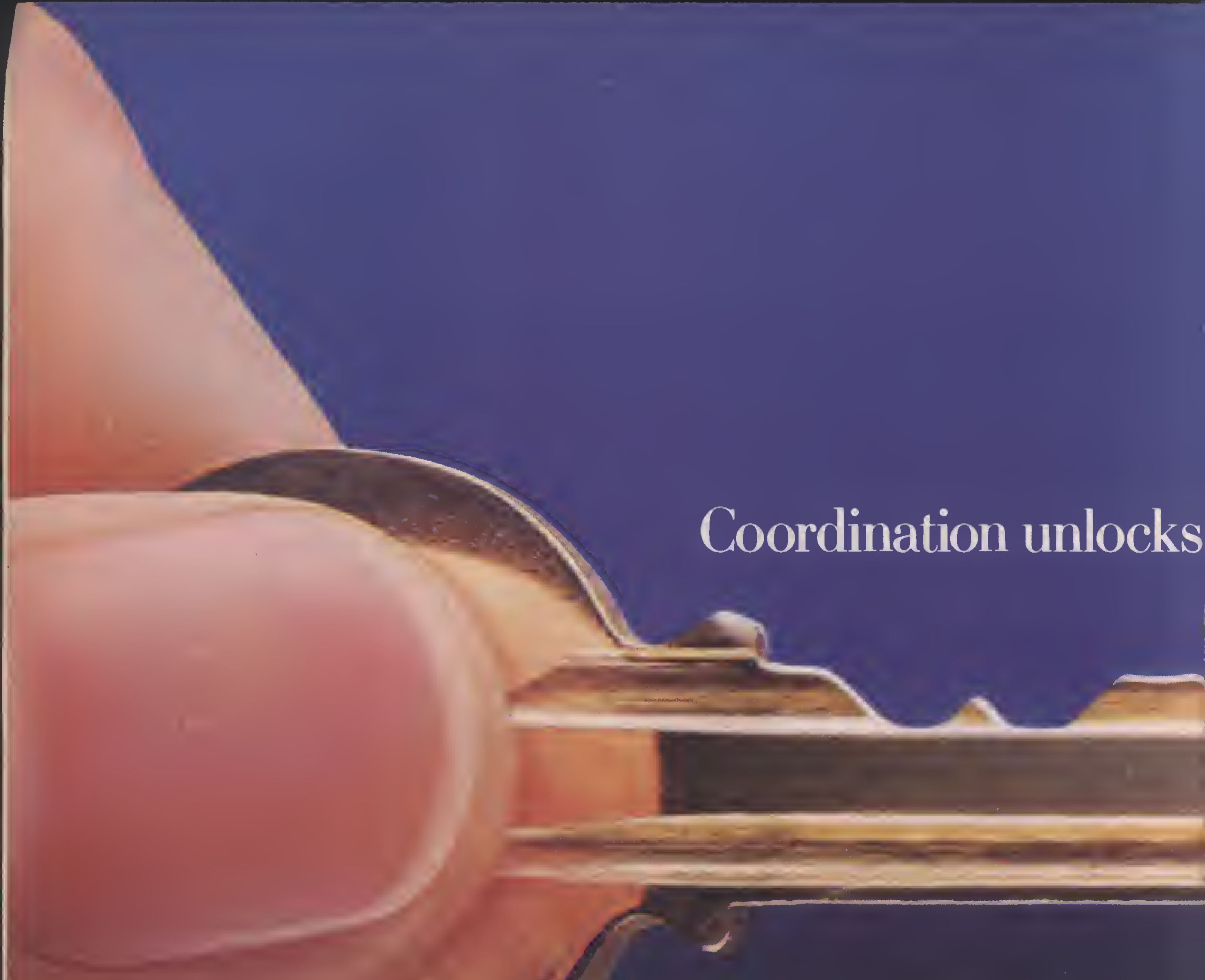
Guess which petunias carry the new gene for herbicide resistance.

Engineered plants resist herbicide

Researchers at Monsanto (St. Louis) have developed a new method for imparting herbicide resistance to crops. While the technique is aimed mainly at boosting sales of one of the company's herbicides, it may also be a means of providing plants with other commercially significant traits, such as improved resistance to drought or salt.

The herbicide in question, called glyphosate, kills virtually all vegetation by disrupting the manufacture of EPSP synthase, an enzyme unique to plants that catalyzes the production of three key amino acids. Working with DNA from petunia cells, Monsanto biologists Robert T. Fraley and Dilip Shah isolated the EPSP synthase gene and transferred it into a bacterium (*A. tumafaciens*) that invades plant DNA. By exposing petunia or tobacco cells to the treated bacteria, the researchers "piggy-backed" the EPSP synthase gene into the plant chromosomes; the modified cells were then grown into whole plants. Because of the extra gene, the plants produced enough of the enzyme to thrive in the presence of glyphosate.

Monsanto hopes that the method will eventually increase sales of its glyphosate-based herbicide, which today must be applied carefully to avoid crop damage. By growing crops reengineered for glyphosate resistance, says a company spokesperson, farmers could rely on a single herbicide—and apply it with fewer hassles.



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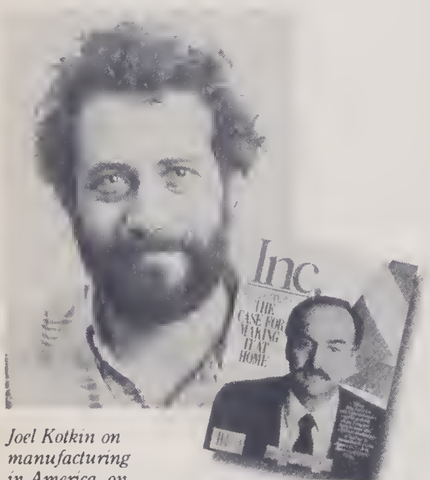

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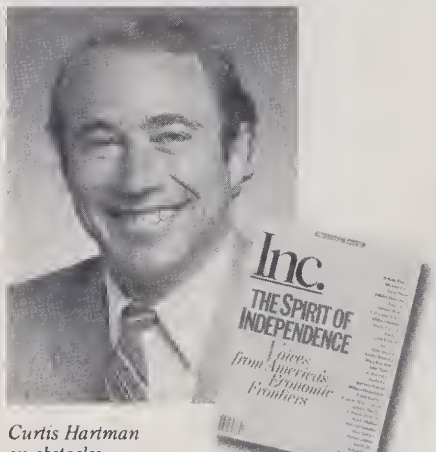

Curtis Hartman on obstacles facing entrepreneurs; on dealing with the press. Inc. senior editor, team leader for coverage of Inc.'s 100 and 500 companies.

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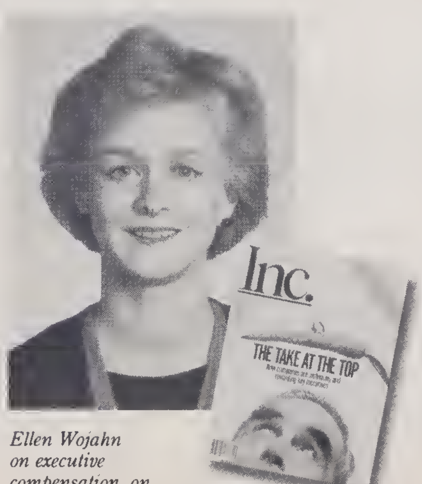

Ellen Wojahn on executive compensation, on management incentive techniques. Inc. associate editor, former radio news anchorwoman.

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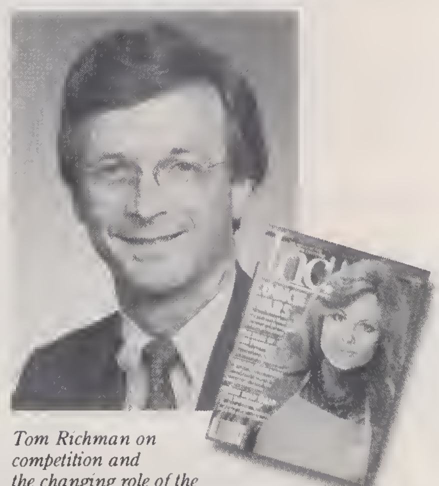

Tom Richman on competition and the changing role of the founder, on effective lobbying, on running public versus private companies. Inc. senior writer, former public TV news anchorman.

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Let the buyer - and the seller - beware

by Susan H. Nycum, Esq.
Gaston Snow & Ely Bartlett

An impediment to the growth of the computer industry is the continuing failure of vendors and users to share risks. It is tempting for each side to point a finger at the other—users maintain that vendors do not provide reasonable product warranties, while vendors assert that users show little respect for their proprietary rights—but the fact is that they must work together to solve the problems that continue to bedevil their transactions. Otherwise, legislatures and the courts will be glad to do it for them.

In more mature industries, risk allocation is an inherent—and deliberate—part of acquisition. Samples, demonstrations, lists of references, and credit checks are routinely provided. Contractual terms and conditions normally fall along predictable lines, as determined by price, business leverage, and negotiation skill. The risks associated with the product or service are thoroughly explored by each party.

Not so with computer-related transactions. In the case of software, users literally cannot see the product, and with sophisticated hardware, they usually cannot take the product or system out for a spin before deciding to buy. In either case, they may not fully understand the product's shortcomings or applicability to their business, and the ever-present technical jargon may bewilder more than enlighten. As a result, it is easy for the customer to passively accept the vendor's standard (usually self-serving) contract.

The Uniform Commercial Code (UCC) that governs the sale of goods—and by judicial custom, computer services in every state but Louisiana—permits vendors' disclaimers of warranties and limitations of liabilities, remedies, and damages. Not surprisingly, these are observed to the hilt in the standard vendor-oriented computer agreement, and the customer who signs one of these contracts takes on disproportionate risks.

Susan H. Nycum, an attorney, is the partner in charge of Gaston Snow & Ely Bartlett's high technology group and managing partner of its Palo Alto office.

In spite of such contractual limitations, most vendors do try to take care of the customer after the sale, often bending over backward to make good on the salesperson's claims. Sometimes they can't, however, and the tough terms of the contract hold.

It is generally no longer necessary to approach the purchase of a business system as if it were a time bomb.

Increasingly, the user goes to court and alleges that the vendor knew or should have known that the product would not work as sold. If the claim is proved, the vendor may pay punitive damages in addition to consequential damages for lost profits and other foreseeable losses. In one such case, *Glovatorium* v. *NCR,* the plaintiff (a first-time computer user) was awarded three days' profits of NCR!

User dissatisfaction has now spilled out of the courts and into the legislatures. In two states, New York and California, special consumer-oriented legislation was recently introduced to curb unfair practices by high technology vendors. The California bill passed the assembly but was finally killed in senate committee, where it was considered overly favorable to users. It sought to remove existing UCC protections for vendors of computer products used in California, and would have made the vendor and its distributors effectively guarantee the product and provide free updates. It also provided for damages of up to two times the loss the customer suffered plus costs and attorney's fees. The New York bill, recently withdrawn for revision, would have required a one-year warranty for all home personal computers.

From years of experience on both sides of the negotiating table, I also know the other extreme: large and sophisticated customers who use their economic leverage, together with their technical expertise, to shift all the risk to the small vendor. These customers demand that all their needs be met before any payment is made and that all errors, regardless of their significance, be corrected. The price of such victory, however, is that the vendor can be squeezed to death, going out of business and leaving the user high and dry.

Another abuse, by microcomputer users, is software piracy—the casual duplication and distribution of protected software without payment of fees to the vendor. Users often defend such practices on the grounds that software licensing based on a separate fee for each computer is unrealistic and that these licenses are grossly overpriced. The result, according to industry estimates, is that there are up to ten unauthorized copies of a successful program for every authorized copy.

All these problems in vendor–user contractual relations can now be corrected. The process won't be easy, but it will be easier than ever before simply because technology has advanced

to the point that such unfair practices and defensive measures are largely outmoded.

The time has passed when all computer-based systems were so experimental that the vendor had to pass on most of the risks in order to sell the product at an acceptable price. As the technology has matured, the really new kinds of systems can now be distinguished from those that are time-tested. Vendors can now economically provide reasonable warranties of performance, maintenance, and service based on the level of experience with the technology and/or the difficulty of application. For software purchasers, it is now possible to try out comprehensive demonstration disks.

Users need not treat every vendor as a bandit who promises the moon but sells only green cheese. Untested, state-of-the-art products certainly continue to warrant special contractual consideration, but it is generally no longer necessary to approach the purchase of a business system as if it were a time bomb. In any case, users buying custom systems should play a more active role by working with the vendor to identify what they need a product to accomplish, rather than passively reacting to a parade of vendors offering general-purpose alternatives.

It is also time for customers of off-the-shelf products to respect the investment and ownership rights of their developers, who in turn can distribute products on terms that encourage good business habits in their customers. Some software houses now offer "site licenses" that allow customers to acquire multiple copies for use at one location at a discount price. The terms vary, but all recognize the user's need for multiple copies and the vendor's need for a reasonable profit.

It makes sense now for each party to stop overprotecting itself from every conceivable risk. In a competitive market, vendors who eschew needless contractual limitations will surely gain a competitive edge. Similarly, customers who know that they can reasonably assume certain risks may find a better business deal than those who stonewall on all issues. Once the real risks are identified, understood, and—where possible—quantified, the actors in the marketplace can arrive at mutually beneficial solutions. But if they fail to act voluntarily, practices may be legislatively or judicially imposed that are not especially helpful to the industry or to computer users. □

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BUSINESS STRATEGIES

Harris:

ACQUIRING LANIER OPENS WINDOW TO OFFICE MARKET

When Harris Corp., a maker of high-end data communications equipment and satellites, announced its intention to acquire Lanier Business Products two years ago, Wall Street analysts snickered. How, they wondered, could a technologically advanced company like Harris get along with Lanier, a maker of dictation machines and other basic office equipment aimed at small businesses? Harris shares fell $4.50 on the New York Stock Exchange the day the deal was announced.

Now, Harris seems to have had the last laugh. "The fact is that the merger worked out great," declares Joseph A. Boyd, Harris chairman. "Lanier is one of the highlights of the company." In the fiscal year ended June 30, Lanier Business Products was a stellar performer in an otherwise lackluster period for Harris (Melbourne, Fla.). Sales for Lanier increased 15.1% to a record $471.4 million, with net income up by 10.8% to $18.4 million, while Harris's overall net income fell slightly, from $80.4 million to $80.3 million, on sales of $2.3 billion. And Lanier accomplished this in a recession that ravaged many other high tech manufacturers.

At first, Lanier remained separate from Harris, retaining its own product development, marketing, and sales support organizations. But in 1985, Harris brought Lanier into its Information Systems Sector, which then became the company's largest division, with $800 million in sales and a third of Harris's 31,000 employees (half are in marketing and sales support). The reorganized division's national-accounts sales force is now based in Dallas and the small-business sales force in Atlanta (Lanier's old headquarters).

By combining and concentrating the two sales organizations, Harris has acted on what some observers long thought was its real motive for the acquisition: injecting some street smarts into its sluggish sales force. "For the last several years," chairman Boyd acknowledges, "our sales and marketing division has not been up to scratch." Lanier's sales force, in contrast, was known for its aggressive style—although some observers questioned whether it could handle Harris's advanced products. This view is snobbish, says Marty Gruhn, VP at The Sierra Group, a Tempe, Ariz., market research firm that advised Harris during the merger. "Selling is selling," she declares, "and the Lanier sales force really knows how to knock on doors."

Lanier is flourishing under the Harris banner, says Jack Davis, head of the parent company's Information Systems Sector.

That's not to say that it's been easy bringing together such dissimilar technology and equipment; Harris is still trying to forge an integrated product line. But by adding Lanier equipment for secretaries and executives to the Harris line of high-performance machines for data processing departments, "we've certainly gotten a broader product family," notes Jack Davis, vice-president of Harris's Information Systems Sector. And the company has gained new territory, he believes, for sales of all its equipment.

Harris is trying to transform itself into a leading office automation vendor, says Geoffrey Hance, research director for the brokerage firm of Blackstock & Co. (Jacksonville, Fla.), and it intends to establish a "strong emphasis on service and customer support, Lanier's traditional trademarks." Since Harris acquired Lanier, it has introduced several new word-processing products and acquired—and subsequently put under Lanier's wing—the sales and service division of Exxon's word-processing equipment subsidiary. In addition to picking up 60,000 customers, "the Exxon acquisition increases Lanier's equipment-rental base by 80% and significantly expands Lanier's very profitable equipment-service business," Hance says. Lanier also handles copying equipment and its line of dictation machines.

Although Harris still has a relatively small part of the office automation market, Sierra's Gruhn rates the company as a successful "niche player," scoring strongly with communications-oriented products. For example, its Concept 6000, a data communications controller that manages traffic for up to 28 workstations, is selling well to law firms and accountants because of its fast file-search capability. The company is also "doing very well selling to the government," Gruhn says, with products such as a digital dictation system that employs random-access hard-disk storage. She also expects "more emphasis on networking" in the near future.

Nevertheless, the good tidings from Lanier couldn't have come at a better time for Harris. With heightened competition for backbone products such as private branch exchanges (PBXs) and IBM-compatible terminals, and an industrywide recession that has depressed its semiconductor sector, the company is struggling to hold the line on earnings. Moreover, Lanier's positive contributions to Harris's fiscal 1985 balance sheet is seen by analysts as no fluke; it is expected to do well again this year. —*Tim Smart*

Fayette Manufacturing:

IS WIND POWER GONE WITH THE TAX CREDITS?

As Hereford cattle graze contentedly below, 5000 turbines spin in the wind that whips through California's Altamont Pass, 60 miles east of San Francisco. The whirling machines transform the wind's energy into electricity, providing a cash crop for entrepreneurs who sell it to Pacific Gas & Electric as an alternative to power generated from fossil fuel or nuclear reactors.

Fayette Manufacturing, based in nearby Tracy, designed and built 1550 of the wind turbines that dot the pass, where the wind blows at a year-round average of 17 miles per hour. Its latest model, selling for $120,000, can generate 95 kilowatts, adequate for the needs of 20 typical U.S. homes. Since John Eckland, president and chief executive officer, bought the young company from a Pennsylvania inventor in 1980, sales have soared from $50,000 to nearly $64 million in 1984, and the employee roster has swelled from three to 200. Fayette estimates that in 1985 it sold Pacific Gas & Electric 60 million kilowatt-hours of wind-generated electricity—enough to power 10,000 households.

A windblown John Eckland of Fayette Manufacturing surveys the company's wind farm in California's Altamont Pass.

"The use of wind for energy is a very old and simple concept," says Eckland, "but the implementation has become very complex." To synchronize its Altamont turbines and put them on line to the utility, Fayette uses a network of computer-controlled switching devices monitored by a DEC minicomputer.

The business aspects of using wind for large-scale generation of electricity are equally complex. Because federal and state tax credits on investments in renewable energy sources applied to the purchaser but not the vendor, Fayette and a handful of similar manufacturers used a rather unconventional method to finance "wind farms" in wind-swept locales (mostly in California). Rather than raising operating capital by selling shares, the small companies sold their turbines to private investors—whose purchase made them eligible for energy tax credits—and installed the machinery on plots subleased to the investors. Fayette and the other small companies then operate the turbines, providing network control, transmission lines to power substations, and other such services.

Despite its rapid growth, the fledgling industry has an uncertain future, as most energy-related tax credits are beginning to come to an end. Starting this month, wind turbine buyers are no longer eligible for the 15% federal tax credit for renewable-energy products. The standard 10% investment tax credit is threatened as well by impending tax reform. In California, state energy tax credits are being reduced this year from 25% to 15% and are scheduled to be eliminated entirely at the end of 1986.

Tom Gray, executive director of the American Wind Energy Association (Washington, D.C.), fears that the elimination of tax incentives could wipe out the young industry just as it is hitting its stride. If tax credits disappear, the industry's total business could drop from a projected $600 million in 1985 to a mere $50 million in 1986, he estimates. Of the 10 wind-turbine companies in the U.S. only four—among them Fayette—are financially strong even now, Gray reckons.

"But if the industry continues to develop," he says, "there certainly is a multibillion-dollar annual market worldwide." In 1978, when the seven-year federal tax credit program went into effect, studies commissioned by General Electric and Lockheed estimated a wind energy market of a trillion kilowatt-hours a year in the U.S. alone. This figure would account for 40% of the country's present electricity consumption. Many industry watchers believe that if wind turbines were to continue receiving tax breaks, the cost of wind-generated electricity would soon begin to approach the 7¢-per-kilowatt-hour cost of oil- and gas-generated electric power. Wind energy now costs 9–20¢ per kilowatt-hour, says Gray, "depending on how much wind is on a site."

However, wind energy's uncertain future is making turbine manufacturers devise business strategies that aren't solely dependent on wind. Fayette's Eckland, the Central Intelligence Agency's chief of petroleum supply analysis from 1973 to 1980, is taking advantage of his background to assess other energy technologies. He's already pursuing a project to increase the efficiency of standard steam turbines through cogeneration. By reusing waste heat with a technique called the Kalina Cycle, Fayette hopes to improve turbine efficiency by as much as 50%. The company plans to build a $10 million test plant next year on its wind farm at Altamont Pass and sell the electricity it generates to PG&E along with its wind-generated product.

For the time being, Fayette intends to stop expanding the wind farm operation, instead concentrating its efforts in wind technology on developing improved turbines. And instead of selling turbines to investors, Eckland speculates, the company may eventually decide to own them—as well as run them—itself. Amidst the uncertainty, one thing remains clear. "As the tax credits end," Eckland says, "our industry will be changing enormously."

—Elizabeth Willson

Micro Linear:

BIG PARTNERS HELP ANALOG CHIP START-UP

How did Micro Linear, a tiny, unproven semiconductor manufacturer, manage to land contracts with some of the world's leading electronic equipment makers? Partly because three of them—Kyocera in Japan, Rockwell in the U.S., and Tadiran in Israel—aren't just customers; they're also financial backers and thus have a vested interest in the young firm's success.

When Micro Linear was formed in October 1983 to produce application-specific analog (often called linear) and mixed analog-digital integrated circuits, the semiconductor industry was booming. The San Jose, Cal., start-up quickly raised $4 million from venture capitalists led by Adler & Co. and Oak Investment Partners. But when it was time for a second—and larger—round of financing to prepare for initial production runs, the worst recession in the history of the semiconductor industry was under way.

"It was a bad time to raise money from venture capitalists at the valuation we wanted," recalls the company's founder and president, Alan B. Grebene—even for niches like custom analog chips, which were unaffected by the downturn. Micro Linear decided to look for a portion of its backing elsewhere, and financing from larger corporations looked like the way to go. Such partnerships can give young companies credibility, as well as access to new markets and distribution networks, says Grebene, and they can help the big companies by giving them an inexpensive avenue to new technologies.

"There's a lot more black magic in linear than in digital circuit design," contends Dan Hutcheson, VP of VLSI Research (San Jose), "and very few experienced linear designers." Micro Linear quickly drew interest as one of a handful of companies (including Telmos, Harris Semiconductor, Intersil, and a few others) that make up the entire custom analog chip industry, with a potentially huge market in equipment for telecommunications, instrumentation, and other applications such as process control. The company was also one of the first to begin automating analog design. By creating a library of designs for chip components, or cells, that customers can mix and match to build application-specific circuits, it eliminates the painstaking manual process that makes most custom designs uneconomical.

Rockwell International (Pittsburgh) was especially interested. Its own semiconductor division was already designing and making custom digital chips, says Jerome A. Early, the company's VP of corporate development, "but we also needed analog capability." Rockwell had recently established a $20 million investment fund, and putting $1.2 million into Micro Linear, he reports, "seemed like a good fit."

When Micro Linear closed its second round of funding in late 1984, it had raised $12 million, of which $8 million came from venture capital firms, and the remaining $4 million from Rockwell, Kyocera, and Tadiran. Company president Grebene estimates that these corporate partners now account for 25–35% of its individual chip designs and its overall sales. "Rockwell alone," he says, "represents a 10–15% chunk" of the projected $4 million in revenues from 30 chip designs expected to be completed—by March 1986—in the firm's first year of production.

One way the company is husbanding its resources is by encouraging its customers' own system designers to help with chip design, using a Micro Linear software package that runs on an IBM PC. "We then take over in the final stages of tooling before fabrication," says Grebene. In the case of Tadiran, Micro Linear is helping set up a design center in Israel to be completed this spring. Tadiran, a manufacturer of telecommunications equipment and military electronics, already has its own digital design center; with the addition of analog capability, it intends to go into the commercial chip business, sending analog designs back to California for fabrication. Micro Linear's relationship with Rockwell is also evolving to include new areas of cooperation. The two companies are currently exchanging technology that involves analog and digital circuit designs, and Rockwell is supplying Micro Linear with silicon wafers.

For the future, Micro Linear hopes its special ties won't preclude doing business with its partners' competitors. Spurred by a boom in military electronics and steady growth in telecommunications, the custom analog chip market "has expanded nicely in the last year," says Hutcheson of VLSI Research. With a healthy base of customers and only a few serious competitors, he adds, "it's a good niche for Micro Linear to be in." ***—Sarah Glazer***

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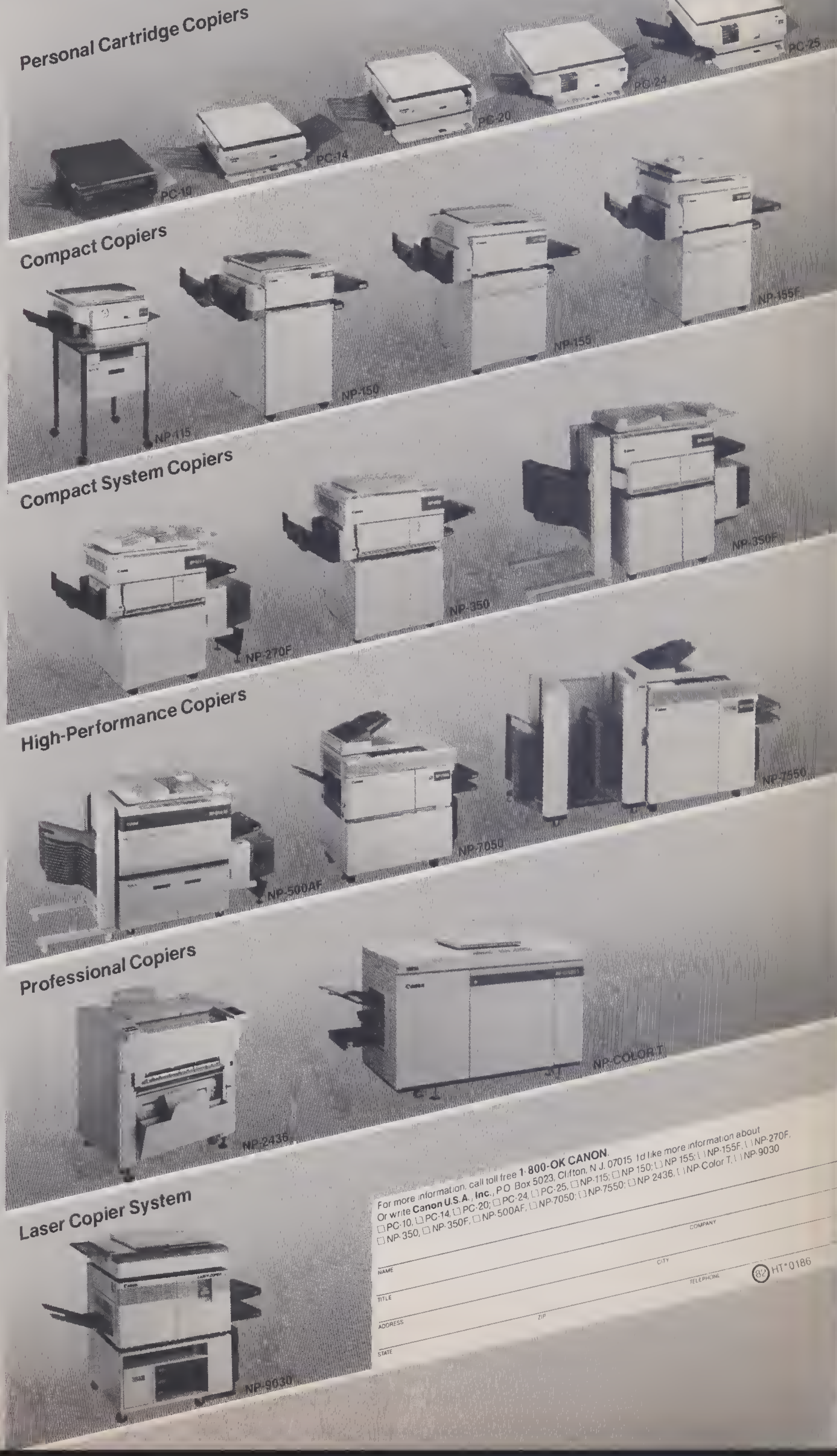

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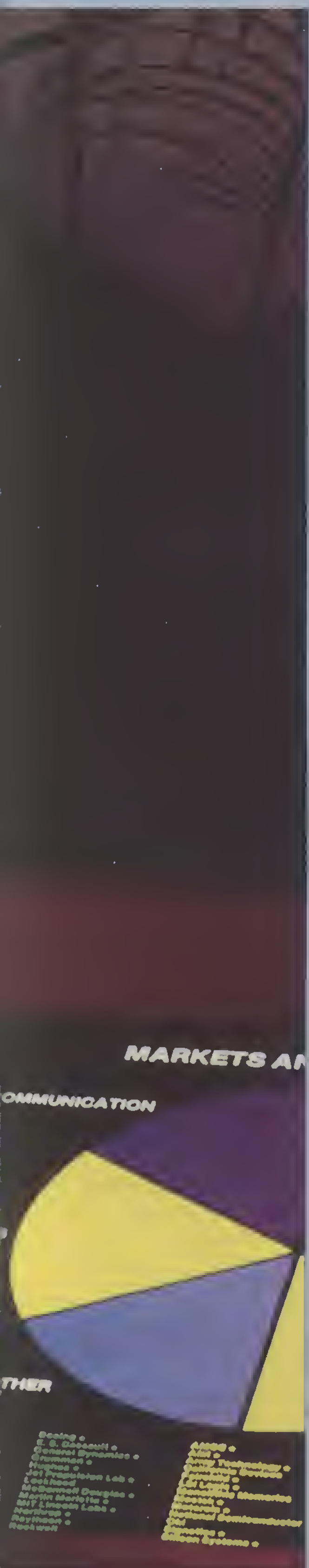


Wide world of EXPORTS

by Jeffrey Bairstow

The thrill of victory belongs to high tech firms that can clear regulatory and cultural hurdles

Last year, for the first time since World War I, the U.S. became a debtor nation. The trade imbalance is estimated at $150 billion for 1985 and could reach $1 trillion by the end of the decade if present trends continue, according to the Business Roundtable, a group of chief executives of large corporations. Although there are no quick and easy solutions to this burgeoning trade gap, one thing is clear: America's exporters must be more aggressive in selling overseas.

U.S. high technology exports continue to grow—from almost $55 billion in 1980 to an estimated $71 billion in 1985—but the balance of trade in high technology goods has declined over that period from $27 billion to $6 billion. The problem is less a slackening in demand for U.S. high technology goods than a steady increase in imports from Japan and the newly industrialized "four tigers of the Orient"—Korea, Taiwan, Singapore, and Hong Kong. Consequently, Congress is under considerable pressure to restrain imports from the Far East. But "to limit imports rather than expanding exports would be the worst move," says Rep. Ed Zschau, chairman of the Republican Task Force on High Technology Initiatives. "What's needed is an environment that encourages competition at home and lets businesses focus on international trade."

High technology goods are already a vital component of the country's exports; according to the U.S. Department of Commerce, they account for almost 45% of the nation's overseas sales. However, even though the activities of such major exporters as Boeing in the aircraft industry, Hewlett-Packard in computers and instruments, and Texas Instruments in the semiconductor field would seem to have led the way, many U.S. companies are still reluctant to enter the export market or are not prepared to make substan-

"*Japanese companies are focused on exports, unlike the majority of U.S. companies. The emphasis must change.*"

Jaseph Boyd, CEO
Harris Corp.

"*It's time we quit finger-pointing and got down to work in reducing the federal budget deficit. Then we'll get more capital investment and a lower dollar.*"

William Krist, Directar af
Internatianal Affairs
American Electranics Associatian

JOHN TROHA/BLACK STAR

"*Be prepared to aim for long-term penetration of a market rather than looking for short-term gains from exports.*"

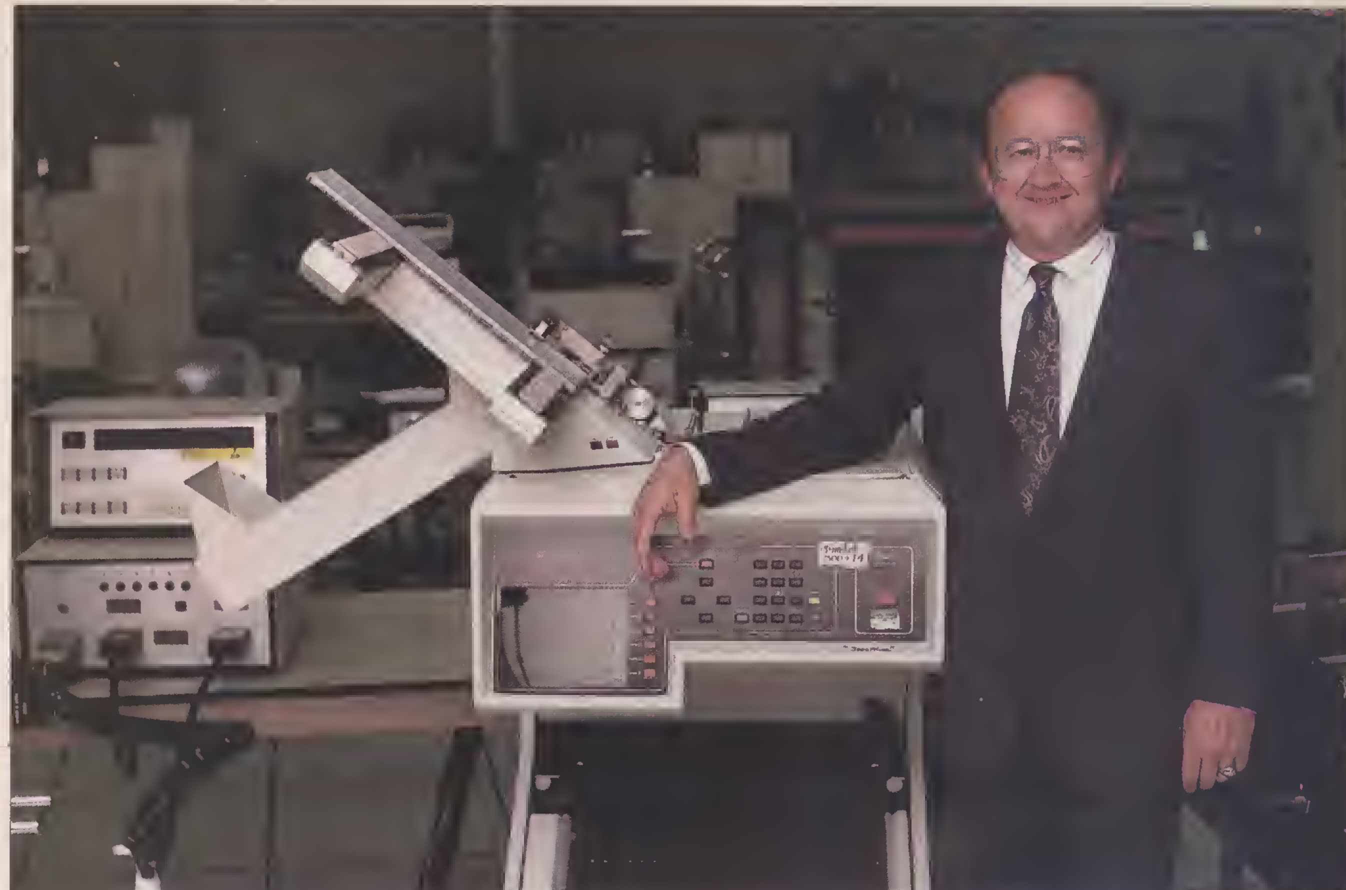
Eckhard Pfeiffer, VP
Eurapean Operatians
Compaq Corp.

tial long-term commitments.The fault is not entirely their own; there are significant barriers that keep potentially serious exporters from entering new overseas markets or increasing foreign sales.

The main problem, economists and businesspeople seem to agree, is the overvalued dollar, which puts American goods at a disadvantage overseas. "If we are to compete worldwide with the Japanese, our dollar needs to be more in line with other currencies," says Donald Brooks, president of Fairchild Camera and Instrument Corp. (Mountain View, Cal.). William Krist, director of international affairs for the American Electronics Association (AEA), believes that the key to lowering the value of the dollar is to reduce the federal budget deficit. This, he claims, would immediately cut back on the nation's borrowing and bring interest rates down. As a result, capital costs (for R&D, for example) would fall, and the flow of foreign capital into dollar investments would slow down, depressing the exchange value of the dollar.

A second barrier to high technology exports is the elaborate system of controls applied by the Department of Defense to technologies that are deemed critical to national security. "We have to get an individual license for every plane we sell to another country, even to Canada," says Edward Coates, director of government affairs for the commercial aircraft division of Boeing. The reason is that aircraft are included in the Pentagon's Militarily Critical Technologies List, which contains more than 4000 entries ranging from laser gyros to expert systems. The Defense Department forbids exportation of these goods to unfriendly nations, including Warsaw Pact members and countries such as Libya and Iran. The Pentagon also prohibits sales to countries that might re-export to an unfriendly nation.

For nonmilitary goods and technologies, export licensing is controlled by the Department of Commerce under the authority of the recently renewed Export Administration Act (EAA) of 1979. How Commerce will set regulations under the 1985 EAA remains to be seen, but in theory the act creates a fast-track mechanism for approving all high technology exports, and curbs the President's ability to use export controls for foreign policy purposes. It also attempts to bring Commerce's commodity control list into line with the less restrictive lists of the Coordinating Committee for Multilateral Export Control (representing the NATO nations plus Iceland and Japan). For exporters with foreign sales operations and dealer networks, the act allows the granting of general distribution li-



CHARLES MOORE/BLACK STARR

censes to cover bulk shipments overseas.

Some 800 companies, many of them high technology firms, now hold distribution licenses. But the Commerce Department, under pressure from the Pentagon and the White House, is reportedly proposing tighter standards and may require some companies now holding distribution licenses to obtain validated licenses for every overseas sale.

Instead of piecemeal attempts to cure the ills of export controls, most exporters would like to see a well-defined U.S. trade policy on a par with those of such countries as Japan, Germany, and France. "We must recognize that international trade is a vital national issue and create an environment for exporters," says Joseph Boyd, CEO of Harris Corp. (Melbourne, Fla.) and a member of the newly formed President's Export Council. The telecommunications market, a major business area for Harris, is often cited as an example of how the lack of a definitive national trade policy hurts U.S. exporters. Since the deregulation of much of the telephone business in the U.S., says the AEA's Krist, "foreign suppliers have had absolutely open access to our markets, while our manufacturers have about a 10,000 to 1 chance of making a sale in Japan and some European countries because their [telecommunications] markets are virtually closed to nondomestic firms."

The industrialized countries may set tariff barriers or national-preference policies, but developing countries can pose even tougher problems for high technology exporters, says Peter Hanley, manager of international government affairs for Hewlett-Packard (Palo Alto). In general, third world countries prefer foreign high technology companies to invest in local plants instead of exporting products. That way, hard currency can be reserved for more basic food and raw-material imports. Hanley also has words of caution about overseas markets that appear huge but that are essentially impregnable. "The People's Republic of China looks like a terrific market for U.S. high technology goods," he says, "but the cost of entry is exceptionally high. Any company going into China must be prepared to invest substantially in joint ventures and education."

"We can take a leadership position in electronics and communications if we sell state-of-the-art and back that with a service orientation."

Donald Brooks, President
Fairchild Camera and Instrument

Political forces are often brought to bear on major high technology sales, particularly where the purchaser is a government-owned enterprise, as in the case of most non-U.S. international airlines. Boeing, for example, goes head to head with Europe's Airbus Industrie (a joint venture of several French, British, and German firms) for large commercial passenger aircraft sales overseas. Price cutting is fierce: In a recent sale to Thai Airways, Airbus cut the price of its A300 plane from $63 million to $43 million in an attempt to beat Boeing's price for the 767. When that didn't work, French, British, and West German diplomats took the offensive in pressuring Thai government officials and Thai Airways executives, ultimately winning the deal for Airbus. Boeing and other U.S. companies simply cannot bring such political firepower to bear on overseas customers, nor can they adopt business practices that would be forbidden under U.S. law.

Despite the problems of doing business overseas, some high technology companies are staking out profitable niches in the export world. They are not only surviving as exporters but are experiencing substantial growth in their overseas markets. While the ingredients for success may vary in each case, two factors appear common: a technology that is either unavailable locally or ahead of the domestic competition, and a long-term commitment to the export market tied to a realization that financial success may not come as quickly as in the U.S. market.

The following case studies of three such companies illustrate the potential for tapping lucrative foreign markets. For Mentor Graphics, the European de-

ROGER MILLER

mand for advanced computer-aided engineering systems for electronic design was so strong that the company had to speed up its plans for overseas expansion. In the case of Compaq Corp., the company's portable IBM-compatible personal computer had no local equivalent in Europe and faced only weak competition from IBM. For Prime Computer's mini- and superminicomputers, the ability to provide sophisticated software—particularly for CAD/CAM applications—has been the key to growing export sales. In each case, the company quickly recognized the export opportunities, capitalized on them, and is currently enjoying considerable success.

"In sports, we train to beat the competition. Similarly, we have to train harder to lead in the export race."

Rep. Ed Zschau, Chairman Republican Committee on High Technology Initiatives

Mentor Graphics

Mentor Graphics of Beaverton, Ore., a computer-aided engineering (CAE) firm founded in 1981 by a group of former Tektronix executives, currently derives almost 40% of its revenues from overseas sales, up from only 12% in 1983. With sales offices in England, France, Germany, Italy, the Netherlands, Sweden, Singapore, and Hong Kong, and a joint venture in Japan with the giant trading corporation Marubeni, Wall Street analysts estimate that overseas sales of Mentor's CAE workstations and software hit $50 million in 1985.

How did a young and relatively inexperienced company manage this sterling performance in such a highly competitive marketplace? "The easiest way would have been to use distributors and let them worry about all the problems of export sales," says president Tom Bruggere. But because the company "made a conscious decision to go overseas for the long haul, not just for a quick profit," it set up its own direct sales and support organizations in the countries where it expected to do significant business. "And from the very first," says Bruggere, "we wanted to hire foreign nationals so that we could behave like a local company and show our long-term commitment."

In keeping with his localization strategy, Bruggere picked Britisher Colin Kidd, an experienced international marketing specialist previously with Intersil, to head Mentor's international operations in Reading, near London. The first move was to the U.K., because "that was the easiest to get into and the largest potential market at the time," recalls Bruggere. Offices in France and Germany followed quickly, staffed with nationals under Kidd's guidance.

The decision to go for direct sales operations was not taken lightly, says Bruggere. "We had to face higher start-up costs and a slower entry than might have been possible with distributors, and we had to worry about operating problems that a distributor would have been expected to take care of." Chief among those problems were fluctuations of both the dollar and local currency, and the procurement of export licenses from the U.S. Department of Commerce.

Mentor currently has a general distribution license for bulk shipments to its European subsidiaries, which does away with the need to obtain a validated license for each system. "But Commerce may soon require validated licenses for all sales to NATO countries," says Peter Schleider, an analyst with L. F. Rothschild, Unterberg, Towbin (New York), "because the government is afraid of the technology getting into Soviet military hands through one of the bogus companies the Russians are reputed to have in Europe. Mentor's sales could run into a

brick wall." A Commerce Department spokesperson would not comment on this allegation. Such a tightening of the rules would certainly inhibit Mentor's overseas growth.

Meanwhile, the company is learning how to deal with foreign laws and customs. For example, Mentor's avowed policy of hiring nationals proved to be difficult in Germany, where restrictive labor laws inhibit the free movement of people between companies. "We found that employees can leave only on a quarterly basis and have to give at least six weeks notice," says Bruggere. Thus the company had to move more slowly in Germany than expected. In Italy, he says, "it came as a shock to realize that 120-day payables are the legal norm—a long time to wait for payment by U.S. standards—but we had to take such things into account as part of the cost of doing business there."

Indeed, the higher costs of doing business overseas, and import duties such as the Common Market's 6% tariff on electronic equipment, raise the prices of U.S. high technology goods quite significantly in Europe. "Our prices are about 15% higher in Europe than in the U.S.," says Bruggere, "but demand is so strong that price is not yet a major factor." Despite some rumblings of CAE activity at such local companies as Britain's Racal-Redac, Mentor's major competitors overseas are still those the company faces at home. That situation may change, however, as Mentor's product line broadens into CAD/CAM systems, where European and Japanese competition may develop.

While Mentor's localization approach though direct subsidiaries was successful in Europe, the company took a different tack in Japan. "The Japanese expect an even higher level of commitment than do the Europeans," says Bruggere, so Mentor formed a joint venture with Marubeni (which owns one-third). "This gave us a Japanese-style company right from the start," he says, "with a group of people who had worked together for several years and had that sense of family that's so important to the Japanese. We could move faster this way than on our own."

The Japanese operation now employs some 70 people and has 40% of the market for CAE systems in Japan, a market driven by a strong demand for consumer electronics. One reason for Mentor's strong Japanese sales, according to Rothschild's Schleider, is that young Japanese designers have pushed for Mentor's Apollo-based workstations, whose advanced Pascal and C language compilers have not previously been available on conventional Japanese computer systems.

The recent downturn in the U.S. semiconductor business has severely affected the U.S. demand for Mentor's CAE workstations, but overseas sales have remained remarkably buoyant. "The economic slowdown in Europe hasn't been as severe as at home, and we've found strong markets in defense, aerospace, and telecommunications," reports Bruggere. "Similarly in Japan, despite some turndown in semiconductors, consumer electronics has been doing exceptionally well for us."

Bruggere offers two pieces of advice for high technology companies looking to export: "First, hire experienced nationals and get them on board as soon as possible. In our overseas offices, we have one or two Americans as technical advisers but none in line management roles. Second, localize your products to reflect international differences. This isn't just a matter of translating documentation. Modify the hardware and software to meet local standards and usage; those adaptations will set you apart from your competition and gain you customer respect."

Quality sells in Japan

"In Japan, you're selling relationships, not products," says Kerry Enright, marketing strategic planning manager at Nihon DEC, the Japanese subsidiary of Digital Equipment Corp. "Japanese customers will test you on your quality, on your performance, and on your delivery. They'll give you requirements that make you want to throw up your hands and scream. But just do what they want. They'll know that if there's ever a problem they can count on you, and you will win the business."

Although the quality of American products has improved in the past few years, less favorable perceptions are still rooted in many Japanese customers' minds. One solution to the problem is to manufacture in Japan; IBM, Burroughs, and Corning Japan have taken that route on at least part of their locally sold products. In contrast, Nihon DEC does almost no manufacturing in Japan, but has a local inspection center where all imported equipment is tested, and repaired if necessary, to meet that country's high expectations for quality. The pressure doesn't stop when the product is made, however. American managers who know their way around the Japanese market stress this point time after time: Quality means "no defects" in the broadest possible sense. As Nihon DEC's Enright points out, " 'Zero defects' doesn't just describe the physical product." The sales and support relationship needs to be utterly flawless in Japanese eyes, too. The purchaser expects suppliers to tackle any problems arising later with as much effort as they applied to winning the business in the first place.

But even after a U.S. company has proved its products and service, "that doesn't mean it can relax," says George Neil, president of Corning Japan; Japanese buyers exert constant pressure on their suppliers. "If you are within specification," he says, "that's not enough. What the customer wants you to do is to constantly *improve* your quality." Says Enright, "There are no final victories."***—Bob Poe***

Compaq Corp.

"Image is a key factor in selling personal computers in Europe," says Eckhard Pfeiffer, the Munich-based vice-president of European operations for Compaq Corp. (Houston). "Sure, we could have formed alliances with distributors and perhaps had a fast start-up, but by going it alone we control every aspect of sales and service." Thus although Compaq has been the most successful of the IBM-compatible personal computer makers in the U.S., the company has moved cautiously in Europe.

"We're looking for long-term market penetration rather than quick, opportunistic sales," says Pfeiffer. "In Germany, in particular, it's important not to move prematurely and disappoint the market with insufficient support." So the company has devoted significant resources to selecting and training its network of authorized dealers.

Compaq began overseas operations in late 1983 with the formation of three wholly owned subsidiaries in Germany, France, and England. Selling started in March 1984 with about 25 dealers signed up in each country, reports Pfeiffer, a former Texas Instruments marketing executive who was enlisted to start the overseas operations. The company now has some 500 dealers in Europe, the Middle East, and Australia, and overseas sales account for about 10% of its $500 million in annual revenues.

Although finding and training dealers at home and abroad is probably the toughest task faced by any personal computer manufacturer, exporting poses other challenges. "Some U.S. companies do not realize that considerable localization of a product is needed for acceptance in Europe," says

Pfeiffer. "Not only must the product conform to safety and technical standards, but changes must be made to hardware and software for local usage. And those changes may be different for each European country." Compaq not only translated all its documentation for European markets but also translated software menus and modified keyboards for European currency symbols and diacritical marks.

Compaq also had to learn how to handle the export licensing requirements of the U.S. Department of Commerce. Pfeiffer agrees that some form of control is necessary for national security: "I'm not complaining; once I know the rules, it's up to me to get on with selling." But he says that a "gigantic effort" was needed over several months to secure a general distribution license for shipping computers to the three European subsidiaries.

The outlook for Compaq in Europe is improving, suggests Michele Preston, a senior technology analyst with Rothschild. "IBM hasn't been as aggressive in Europe as in the U.S., which has allowed Compaq to get a good foothold in the growing European marketplace," she says. "And because we feel

"Each country is different. You need local people who understand local markets."

Richard Williams, VP
International Marketing Operations
Prime Computer

that Europe is lagging the U.S. by about 18 months, the real boom in personal computers is yet to come there." When that boom arrives, Preston expects Compaq's export sales to rise from 10% to as much as 20% of its total revenues.

For the future, says Pfeiffer, Compaq will continue its policy of careful selection and strong support of dealers, "with even more localization of the product." The company has no immediate plans to manufacture overseas, but "that will not be necessary," says John Webster, a research analyst with Underwood, Neuhaus (Dallas): "Compaq's U.S. engineers not only have a development time [for new systems] of only nine months versus two years for IBM, but the company's manufacturing line can change quickly from one product line to another." These advantages, together with Compaq's strong oversees dealer network, lead Webster to conclude that the company is in a good position to respond to rapidly changing demands in foreign markets.

Prime Computer

"You've got to be attentive to all the opportunities in export markets," says Richard Williams, vice-president of international marketing operations for Prime Computer (Natick, Mass.)—even though these markets are far from homogeneous and often completely unlike the U.S. marketplace. In 1985, foreign markets accounted for close to 50% of Prime's product sales, or almost $400 million, according to Wall Street estimates. "We're seeing 45 to 60% annual growth rates in places such as Germany, Australia, Scandinavia, and Switzerland," reports Williams.

The company sells to more than 50 countries around the world, with over a dozen foreign subsidiaries providing sales and support in countries with major markets. Other countries with smaller markets are handled by local distributors. After the boom years of the late 1970s, Prime also decided to build a manufacturing plant in Ireland, mainly to be able to ship to nearby European markets, but that facility now builds systems for export to countries as far away as Australia.

In keeping with the sophistication of Prime's computer products, the industrialized countries of Europe remain a major focus. "Everybody seems to be on a productivity kick in Europe at the moment," says Williams, "so we're doing particularly well with our CAD/CAM systems." For now, Prime appears to face little competition in that area from local suppliers. There is some pressure from governments for domestic purchasing, he says, but local suppliers usually "can't offer the same range of hardware and software. The competition is pretty much the same companies we face at home."

Prime is attempting to be a full-service computer supplier to these markets, a role that may "eventually call for more resources than Prime can afford," says Philip Cavalier, vice-president of the Pershing Division of Donaldson, Lufkin, Jenrette (New York). "As European customers look for companies that can supply everything from mainframes to desktop computers and the communications links between them," he says, Prime may have to join forces with other computer makers.

In Japan, Prime's progress has been less dramatic. The company had been using a Japanese distributor, but a year

ago it bought its own distributor and is now revamping its Japanese operations. "My guess is that we're at less than 5% of our potential in Japan right now," says Williams, "but the front-end investment to reach that potential is considerable." He cites the need to extensively modify hardware, software, and documentation for Japanese users.

When Prime bought its Japanese distributor, the employees were kept on, in keeping with company policy. Better than 99% of Prime's overseas personnel are nationals, estimates Williams: "No matter how much international experience a person has, we're all nationals. A Frenchman will always understand the French customers' needs better."

Prime's strategy in Europe appears to be to lean heavily on its expertise in CAD/CAM systems while stressing that it is a full-service computer company providing such capabilities as office automation, telecommunications, and data management. The CAD/CAM emphasis has become much stronger since Andrew Knowles, a former DEC vice-president, became Prime's VP of computer-aided design and manufacturing early in 1985. Knowles, an engineer by training and a marketer by experience, sees CAD/CAM as leading to the integration of manufacturing and administration (naturally, he forsees Prime systems handling all the distributed functions). "But CAD/CAM is going to be a tough row to hoe," says Rothschild's Schleider. "There's serious competition from the turnkey players, such as Computervision and Intergraph, to say nothing of the threat of IBM. And European competitors are beginning to pick up U.S. technology, too."

Advanced technology sells in Europe

Because of the strong dollar and tariff barriers for electronic components and computer systems, American products sold across the Atlantic generally cost about 30% more than their European equivalents, says Arthur Reichenbach, trade adviser at the U.S. Embassy in Vienna. Even so, U.S. high technology products are strongly in demand in Western Europe. In West Germany, for example, American firms sold an estimated $1.3 billion worth of computers and peripheral equipment in 1985, according to a recent U.S. Embassy commercial survey. The market leaders—IBM, Apple, and Hewlett-Packard—will help U.S. firms capture 30% of the computer market in West Germany, versus only 13% for British and Japanese makers.

What sells Europeans on U.S. high technology products despite their stiff prices? Local technological disadvantage. "We're two years behind," says Harald Brand, a trade analyst with West Germany's Business Machines and Data Processing Equipment Association in Frankfurt. "To get the latest in technology, West German firms must import."

Thus, high technology firms with the right product can find lucrative market niches and good profits in Europe. Moreover, exports of high technology goods to Europe are expected to grow substantially, according to recent surveys conducted by the U.S. Department of Commerce. Exports of aircraft and parts in 1985 were running at a $2.5 billion rate, more than 50% higher than the previous year, and the recent decline in the dollar is expected to broaden the prospects for high technology goods even more, says Commerce. Over the longer term, Commerce claims, changes in economic policies in European countries to increase employment are likely to stimulate private investment and consumption, further increasing the demand for U.S. high technology goods. ***—Dennis Phillips***

The world according to Commerce

The most important markets for U.S. high technology goods continue to be the developed countries, particularly Canada, Japan, and the European Common Market, which account for more than 60% of U.S. high technology exports, according to recent Commerce Department studies. Canada's continuing economic slowdown is expected to result in lower U.S. export growth generally, but demand remains strong for business equipment and computers.

Exports to Japan are also expected to grow, the rate depending to some degree on the progress to be achieved by the market-oriented, sector-selective (MOSS) negotiations currently taking place between the U.S. and Japan. The MOSS talks are focused on telecommunications, electronics, forest products, medical equipment, and pharmaceuticals. (One result of the MOSS talks is that U.S. manufacturers of certain types of medical equipment and drugs will no longer be required to have their products tested by an independent Japanese laboratory. This has been a time-consuming and expensive requirement that has made U.S. products higher-priced than their Japanese equivalents.)

The best prospects for export to Japan, according to Commerce, include computers and software, CAD/CAM systems, aircraft and parts, telecommunications equipment, and medical and dental equipment.

In Europe, reports Commerce, modest economic growth and a decline of the dollar from its heights of early 1985 are gradually improving the outlook for technologically advanced products. Exports to Denmark, Austria, and Yugoslavia have been growing the fastest, but the two biggest markets are still the United Kingdom and Germany. In the U.K., opportunities exist for strong sales of electronics production and test equipment, telecommunications equipment, process controls, printing and graphic arts equipment, and medical equipment, says Commerce. In Germany, the export outlook is strong for computers and software; recent industrial surveys project a 20% annual growth in office automation—as well as in pollution controls and instrumentation—because of heightened public awareness and tougher environmental legislation.

While U.S. high-technology exports to the developing Latin American and OPEC nations have been declining, exports to the newly industrialized countries (NICs) of East Asia—Hong Kong, Taiwan, Korea, and Singapore—have been increasing steadily; between 1980 and 1984 they grew from $4.5 billion to $6.3 billion. Commerce Department analysts point out that the rapidly growing high technology industries in these countries need sophisticated production and test equipment that is often available only from the United States. Electronic equipment, medical equipment, and telecommunications systems are in high demand in the East Asian NICs, reports Commerce.

While the prospects for increased international high technology trade remain strong, the battle is getting tougher. "In electronics, local and international competition for markets has turned into a real horse race," says Boyd McKelvain, manager of trade relations for General Electric (Fairfield, Conn.). "Yet U.S. companies have to recognize that we need to succeed in the worldwide markets in order to survive." Rep. Zschau agrees: "We have to stop regarding exports as gravy. It's time [U.S. companies] realized we have to go toe to toe in foreign markets to be competitive at home." □

Jeffrey Bairstow is a senior editor of HIGH TECHNOLOGY.

For further information see **RESOURCES**, *p. 68.*

Artificial Intelligence:

Summary:
GTE research in Artificial Intelligence has produced exciting results in several areas of knowledge-based systems. In addition, research is under way to teach computers to learn by themselves, much as humans do.

It's extremely tedious and difficult to teach a computer to respond to specific problems in an intelligent way. Despite this, GTE has created several workable systems, which are in the field now.

But training a computer to respond to analogous or unexpected situations —teaching it to *learn*—is a very different challenge. And this is one of our long-range programs in AI research.

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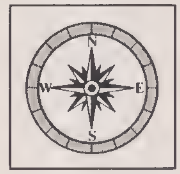
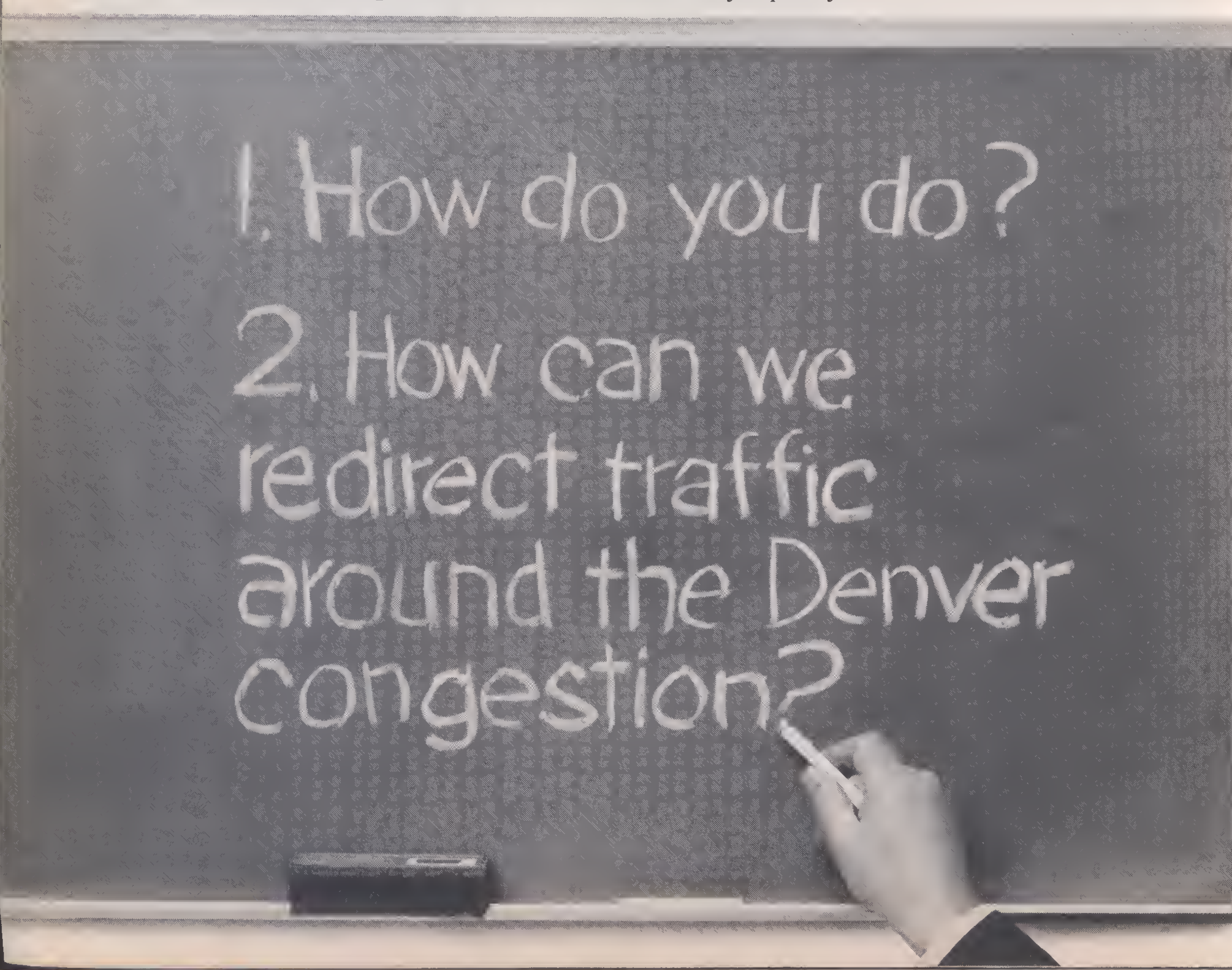


COMPASS (Central Office Maintenance Printout Analysis and Suggestion System) is an Expert System we devised for telecommunications. It is being phased into field use to monitor switch per-

Which of these questions is easier for a computer to answer?
The apparently simple greeting is loaded with semantic traps. On the other hand, the complex question relating to traffic redirection can be tackled by Expert Systems.



reality and promise.

formance, diagnose problems and recommend corrective actions in large communications networks.

Say hello to FRED.

The proliferation of databases and their integration in a large information system is increasing computer uses. Increasing user friendliness is becoming all the more necessary for computers to be used by less skilled operators.

GTE has developed FRED (Front End for Databases), which enables operators to frame information requests from multiple databases, in plain English. FRED untangles the request, breaks it into segments the computer understands—and provides the data, in plain English.

For its next evolution, we are teaching FRED to approach several databases at once (rather than one at a time), and put all relevant data into a single reply.

The nature of thought.

Another of our AI research directions is basic, long-range research into ways of teaching computers to learn for themselves, through experience and/or inference.

This involves research into such an area as the way children learn, as well as deep studies into the nature of decision-making itself.

Much remains to be discovered, of course—but the promise of true machine learning is perhaps the most exciting in the entire computer field.

The outcome of these projects—some near-term, some more in the future—will be to make the computer a far more useful and friendly tool for an immense variety of industrial and human problems.

The box lists some of the pertinent papers GTE personnel have published on various aspects of Artificial Intelligence. For any of these, you are invited to write to GTE Marketing Services Center, Department AI, 70 Empire Drive, West Seneca, NY 14224. Or call 1-800-828-7280 (in New York State 1-800-462-1075).

Pertinent Papers

"COMPASS: An Expert System for Telephone Switch Maintenance," S.K. Goyal, D.S. Prerau, A.V. Lemmon, A.S. Gunderson and R.E. Reinke, Expert Systems: The International Journal of Knowledge Engineering, *Vol. 2, No. 3, August 1985. pp 112-126.*

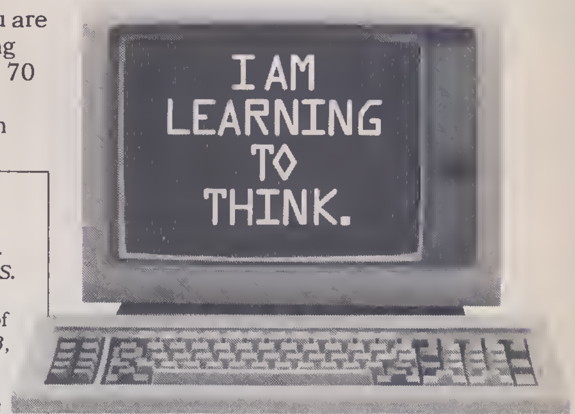
"Selection of an Appropriate Domain for an Expert System," D.S. Prerau, AI Magazine, *Vol. 4, No. 2, Summer 1985; pp 26-30.*

"A Natural Language Interface for Medical Information Retrieval," G. Jakobson, C. LaFond, E. Nyberg and V. Shaked. Third AASMI Joint National Congress on Computer Applications in Medicine, May 1984, San Francisco, California. pp 405-409.

Computer Experience and Cognitive Development, *R.W. Lawler. Ellis Horwood Limited, Chichester, U.K. (1985). (Summary of book.)*

"The Learning of World Models by Connectionist Networks," R.S. Sutton and B. Pinette. Proceedings of the Seventh Annual Conference on Cognitive Science Society, 54 (August 1985).

"Training and Tracking in Robotics," O.G. Selfridge, R.S. Sutton, A.G. Barto. Proceedings of the Ninth International Joint Conference on Artificial Intelligence, 670 (August 1985).



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THE STATE OF THE MICRO

A survey of products and trends in a beleaguered market

by Cary Lu

Nineteen eighty-five was not very kind to the microcomputer industry. The pace of new developments slowed visibly. The industry is still growing rapidly by ordinary standards, but far below the optimistic projections that the many new start-up companies had been counting on. And the most advanced software is now running into hardware limitations.

The industry is at the beginning of a major transformation. With the shift from text-based software to graphics-based software, computer displays and printers will cease operating as if they were merely typewriters; the visual richness of typography and graphics will become universal. In addition, graphics-based software promises a common interface, so skills you gain from using a word processor will apply to a spreadsheet or database program as well. And because the microcomputer industry is actually adopting a graphics-interface standard by consensus, skills will be transferable between machines as well as programs; you will be able to go from a Macintosh to an Amiga to an Atari ST to a suitably equipped IBM PC with little hesitation.

The overwhelming advantages of graphics-based software are evident from the Apple Macintosh. In virtually every category, Macintosh software outperforms IBM PC software. Mac programs have always been easier to learn and use, and now they are getting more powerful as well. For example, Excel is the best spreadsheet now available for any computer, far superior to Lotus 1-2-3 or any other MS-DOS spreadsheet—in power and ease of use alike. And Macintosh programs can exchange data (both words and pictures) much more readily than MS-DOS programs. You can take text, graphs, or pictures from most Macintosh programs and plop them into another program. Not every program will accept every type of data, but several database programs will accept pictures as data, and all the word processors let you include pictures with the text.

A major challenge facing the industry is devising a way to get modern software onto the IBM PC class of computers. Software development for the IBM PC in 1985 slowed considerably, for several reasons. First, the marketplace is glutted; getting a new product launched requires a major investment. Second, better software needs an effective graphics display and a mouse, and few PCs currently have both. Finally, the standard IBM PC is running out of power, in both processor capability and memory addressing, and thus cannot run the new graphics-based software adequately. While the PC/AT and its clones have the necessary power, their advantages are not yet compelling for many buyers, because they cost more (although the gap is narrowing) and so far offer little more than the ability to run the old software faster. With the coming graphics-based software, however, such speed improvements are crucial. And in the long run, the AT's capacity for 15 megabytes of directly addressed memory will let it run much more sophisticated software.

To make the original PC compute faster, several companies make add-on boards that contain an 8086 or 80286 processor with its own memory. But these boards are merely an expensive stopgap solution and often cost as much as trading up to a PC/AT.

The other major problem on the PC series is the lack of memory. Although 8088- and 8086-based microcomputers can address a full megabyte directly, the IBM PC actually addresses only 640 kilobytes after housekeeping functions. The only way to use more memory is via bank switching, a technique that temporarily switches blocks of memory addresses from one set of RAM chips to another. Bank-switching schemes—such as the Lotus/Intel/Microsoft Extended Memory Specification, as well as the AST/Quadram/Ashton-Tate variation—are clumsy, but they will prolong the PC's working life. Banked memory works mainly for data files; programs can occupy the memory only under severe restrictions. As a practical matter, such additional data memory may only encourage poor working habits, by tempting users to create ever larger and less manageable spreadsheets.

The open architecture—the ability to open up the case and install circuit boards from many vendors—that is widely admired on the IBM PC has turned out to be a liability in some ways. Since the PC comes in many configurations, software developers commonly write programs that can run under the most primitive conditions; thus most IBM PC programs do not as-

WATERCOLORS BY KATHERINE MAHONEY

sume that the computer has any graphics display capability at all. This lack of screen graphics inhibits better software for the PC. Both of IBM's original display adapters are obsolete: The Color Graphics Adapter has unacceptably poor resolution, and the Monochrome Display Adapter can't deal with graphics.

Everyone using a PC with a monochrome screen should upgrade to a Hercules Graphics Card or its equivalent. If you want color, IBM's Enhanced Graphics Adapter (EGA) is the adapter of choice, but software support for it has been slow. Since the EGA will emulate the earlier IBM adapters, you can use it while waiting for improved software—although EGA clones from independent companies will probably be a better choice (some of them will emulate the Hercules card as well). Unfortunately, no common IBM display adapter uses square pixels with the same density in vertical and horizontal directions, so graphics images never work quite as smoothly as on the Macintosh.

If the PC/AT has no software to show off its computing prowess, the Macintosh situation is practically reversed: Mac software shows off all too clearly Apple's underdesigned hardware. For all its elegance, the Macintosh desperately needs more memory; 512 kilobytes simply cannot accommodate the needs of a serious user. As a result, a small cottage industry has grown up to install additional memory, up to 4 megabytes. In principle, memory expansion is simple, because the 68000 CPU needs no bank-switching tricks. But the Macintosh ROM that orchestrates its operation is designed for 128 or 512 kilobytes; adding more memory requires either a modified ROM or some limitations on memory addressing. So each aftermarket installer has done the memory extension in a slightly different way, and Apple will inevitably do the "official" expansion in yet another way, because it will also make changes in the ROM. The 68000 CPU can address 16 megabytes, but unfortunately the Mac's design permits only 4 megabytes (thanks to a design decision that saved two wires on the circuit board).

The Macintosh also needs a way to connect hard disks gracefully. All the present Mac hard disks have a problem of one sort or another. Every external hard disk drive, including Apple's 20-megabyte unit, works sluggishly because all the available input/output ports are slow. The Apple drive, however, benefits from a new hierarchical file structure, and it is the most cost-effective Mac hard disk drive. The more expensive HyperDrive hard disk from General Computer connects internally for faster operation, but like other third-party disk drives, it will lag behind Apple's own products in software support. Most Macintosh hard disk drives are low-performance stepper motor designs, similar to the IBM PC/XT hard disks; the PC/AT uses medium-performance linear motor or high-performance voice coil hard disks.

Despite the problems, every Macintosh has a graphics screen and a mouse and thus has no problem running graphics-based software. And forthcoming Macintosh models will solve the memory and hard disk problems, as well as provide for larger video screens; a new chassis will accept circuit boards for expansion.

If a situation calls for more than one microcomputer, you can operate IBM PCs and Macintoshes together, using each to its best advantage. Such operation is becoming more practical as network hardware and software support appears. On the low-cost, modest-performance AppleTalk network, Tangent Technologies supplies an AppleTalk interface board for the PC along with software for electronic mail and MS-DOS printer drivers for the Apple LaserWriter. Centram Systems has networking software that lets PCs and Macs share disk files from any computer on the network. A network configuration from 3Com can tie the Macintoshes together with AppleTalk and then link the Macs to IBM PCs with Ethernet. Excel can read 1-2-3 files directly. You can use a Mac to polish a spreadsheet that was originated on an IBM PC, and then move everything to a page makeup program to add graphics. This will produce a much more professional-looking printed report in far less time than trying to do everything on the IBM PC.

Of course, the IBM PC and the Macintosh are not the only choices. Some of the IBM PC clones, for example, have tried to improve on the original, and lightweight portables—though still weak when it comes to displays—are steadily growing in sophistication.

If you decide to buy an IBM PC compatible, you have a wide selection to choose from. The newest clones copy the PC/AT design. This time around, everyone has taken the lessons of the early PC clones to heart and is trying to get as compatible as possible. All the AT clones from the major vendors seem to work adequately. The common improvement is modestly faster operation—8 megahertz instead of the PC/AT's 6 megahertz, and slightly improved memory access time. The Compaq 286 continues to come bundled with a dual-mode display adapter that should be discontinued; it essentially emulates the two unsatisfactory IBM display adapters, so Compaq owners wanting a decent display must get a Hercules or EGA board.

If you are not willing to spend the money for an AT or the equivalent, you may as well get the cheapest acceptable IBM PC or clone you can find. It must incorporate the essential features: provision for 640 kilobytes of memory, a clock/calendar, serial and parallel ports, and an acceptable display driver and keyboard. The cheapest system with everything is the $1500 Leading Edge model D, made by Daewoo in South Korea. It includes both a Hercules-compatible and a Color Graphics–compatible display adapter, and thus offers a better display than any other off-the-shelf PC clone. Its keyboard layout and feel are above average for a look-alike.

The first interesting PC clone to come from Japan is the Panasonic Executive Partner, a transportable computer with a plasma display. At 28 pounds, it's just as heavy as the traditional CRT units, but its flat case is easier to carry than the usual box. The keyboard is satisfactorily laid out, with function keys along the top; its feel, however, is poor—about the same as the Compaq's. A built-in thermal printer makes the Executive Partner a nearly complete computer system, but is small in both size and performance (a pity it isn't removable). The 640 × 400–pixel plasma display always runs in IBM graphics mode, but with its own legible font for text, much better than the 640 × 200 variety. For standard graphics, the display controller doubles up adjacent pixels for an effective resolution of 640 × 200 pixels.

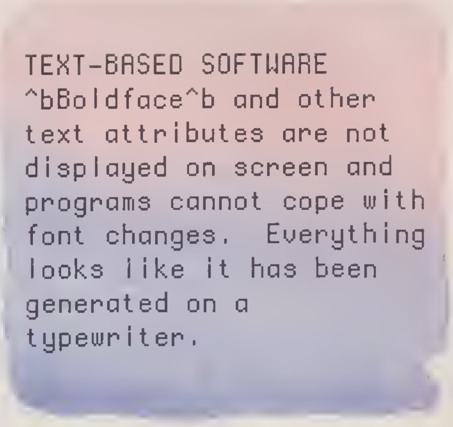
If you buy an IBM PC or compatible, you should consider a subtle but potentially important problem: You may not find the same keyboard layout on other machines you may use, and the reflexes you learn with IBM's function keys to the left of the keyboard don't help when you are confronted with function keys laid out along the top. There is nothing inherently better or worse about either arrangement, but getting used to one layout creates confusion when moving to another.

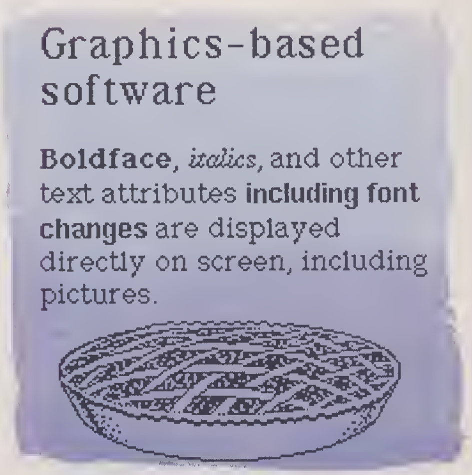
Smaller, more portable computers are still stymied by display problems. A satisfactory display should combine high readability and low power consumption. But such displays do not exist now and are unlikely in the near future; current portables must make do with liquid crystal displays, the only lower-power technology commercially available. Adding a backlight to LCDs (as Morrow, Sharp, and others do) improves visibility a little but also eats up battery power (Sharp doesn't attempt

battery operation and throws in a printer): The best small unit on the market is the forthcoming version of the Data General/One with an electroluminescent display. It will soon be able to run on batteries—but not for very long, so it isn't a true portable.

Among the present true portables, the relatively low-cost Radio Shack Model 200 is attractive for its light weight (5 pounds) and good keyboard layout (marred by poor keyboard feel). It displays only 16 lines of 40 columns each, but the characters are larger and more legible than on its 80-column cousins. It is a good choice for computing on the run, even though it cannot handle MS-DOS software.

For more computing power, the logical extension of the Model 200 is an 8088-based portable, although such machines are heavier and more expensive. The new Model 600 from Radio Shack ($2000 including a microfloppy disk drive and sufficient memory) and a similar unit from Zenith (about $1500 with memory but no disk drive) contain the new Microsoft Works software in ROM. Hewlett-Packard's Portable Plus is a considerable improvement over its predecessor, the Model 110. It is expensive (over $3000 with software) and a little heavy (8 pounds), but it runs MS-DOS software (in a special ROM form) and operates for 20 hours on a battery charge—something that no IBM PC compatible can do. If you need IBM compatibility and can live with limited battery operation, there's the Morrow Pivot/Zenith Z-171, which can run for about four hours off batteries and has a back-lit display that's much better than the Kaypro 2000's.





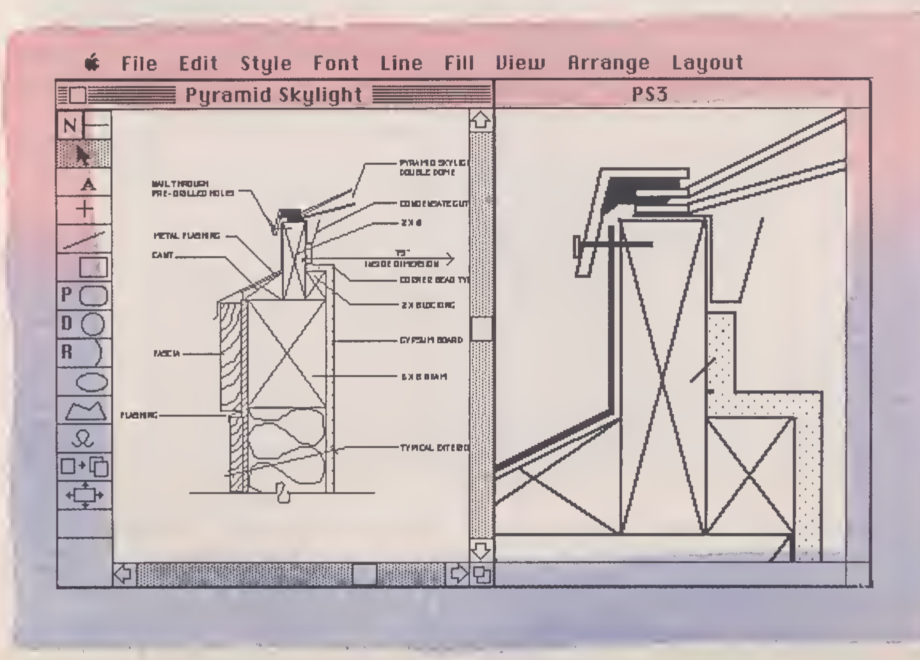
All the new portables share a serious problem in an airplane seat, because the screen folds up from the keyboard. If the person in front leans back, you won't have enough space—at least not in coach. The venerable Radio Shack Model 100, however, works everywhere because its nonfolding screen is small and the character size relatively large.

Despite the industry slowdown, the past year has brought still more software. Obsolescent hardware notwithstanding, software improvements for the IBM personal computer continue. And on the Macintosh, 1985 brought software for all common applications and many specialized areas as well.

The most important software packages introduced for the IBM PC in 1985 are the graphics-based "environments": Digital Research's GEM and Microsoft's Windows. These products create the software equivalent of the Macintosh on the PC, replacing MS-DOS's cryptic interface with icons and pull-down menus on the image of a desktop. You give commands by pointing with a mouse instead of memorizing instructions to type. Although ordinary MS-DOS programs can be run from GEM or Windows, these environments will shine only when rewritten software embraces their operational style. The initial versions of GEM were so like the Macintosh that Apple objected and Digital Research is now modifying its design. GEM (first version) and Windows are similar enough that you can go from one to the other with few problems; in fact, you can install both on a single computer. From a practical standpoint, the only important question is which will get more software support. While the market is deciding who wins or loses, all serious IBM PC users should try one or both to explore graphics-based software. (TopView from IBM and DesqView from Desq include some similar functions, but both are text-based and thus represent older technology.)

Among the new database programs for the IBM PC, Q&A from Symantec offers the power of pfs:File, Report, and Write (same as IBM's Assistant series) in a single, superior package. Q&A does not attempt to compete with the heavyweight programs, but it has a well-designed natural-language command system incorporated into its database functions.

The major new heavyweight database is Paradox from Ansa. It offers roughly the same functions as dBase III, with faster operation and a style patterned after Lotus 1-2-3. The interface does not work as well as 1-2-3, partly because databases are inherently more complex than spreadsheets but also because of rough edges in the initial release. The programming language built into Paradox is sufficiently different from dBase that programmers who use that language will probably not change over; new users will find



MacDraft on the Macintosh offers easy operation and powerful features. This architectural drawing of a skylight was done by Greg Wolters for David Wright and Associates.

Amiga and Atari ST

The splashiest microcomputer introductions in 1985 were for the Atari ST and the Commodore Amiga. At about $1100 and $2100 respectively (with a monitor and second disk drive), both target a gray area between home and professional uses. And both face major challenges in getting software support. They will have a harder time than the Macintosh because financial realities have made investment capital hard to find. When the Macintosh came out, companies were much more willing to take the risk to develop software. Since Macintosh sales have proved disappointing, most major software companies are holding off on the new micros.

Technically, the Amiga is more interesting than the Atari because of its special-purpose graphics processor, but the Atari is cheaper. The Amiga was originally conceived as a game machine, and its display prevents it from working well for serious users. In order to work with relatively low-cost monitors, Amiga chose a 640 × 200–pixel mode with unacceptably poor resolution for text or graphics (the same problem as the IBM Color Graphics Adapter) and a 640 × 400–pixel interlaced mode with a flickering image. Amiga could correct this problem with more expensive monitors and redesigned system software.

One unusual feature the Amiga has demonstrated in unfinished form is an 8088 CPU emulator that can run some unmodified IBM PC software. The advantages are obvious, but such an ability may also discourage Amiga-specific software. Vendors may tell prospective buyers to get the IBM PC version, so users will again get stuck with text-based software again. Indeed, several programs announced by Commodore are text-based even though they work in Amiga's native mode.

The Atari ST offers more raw performance for the price than any other microcomputer, but software is appearing only slowly. The ST deserves to succeed for its potential to deliver worthy technology to a wide audience, yet market uncertainties have thus far left most software developers skeptical.

Commodore's new Amiga computer incorporates specialized processors to handle graphics and sound generation. The challenge will be getting developers to write software; economic conditions are not favorable to new projects.

Paradox easier to master, particularly if they have 1-2-3 experience.

The simpler Reflex database from Borland works with a single file at a time held in RAM, so it is very fast. It is excellent for looking at data and can read both 1-2-3 and dBase files.

For analyzing numbers, the traditional choice has been spreadsheets. But Javelin claims it will replace spreadsheets with its new analysis program. The package works with named variables rather than spreadsheet cells, allowing you to type, say, "profits = income + expenses," instead of "D5 = C4 + B3." Actually, some spreadsheets also let you name variables, so Javelin's applications overlap rather than replace spreadsheets. Javelin does provide several ways to look at data interactively, including a nice graph mode where you can change a value by moving the data point on the graph. Judging from the prerelease demonstrations, Javelin is a good choice for large, complex jobs, especially if you are having trouble keeping track of an intricate spreadsheet that you cannot break down into smaller components.

Application software for the Macintosh now runs the gamut from drafting to heavyweight databases. MacDraw, Apple's structured drawing program, works smoothly, but MacDraft from Innovative Data Design is even better, especially for precise work such as architectural plans. Casual users, however, may prefer MacDraw for a key feature: its ability to resize individual objects. For animated drawings, Hayden Software's VideoWorks delivers the action with a particularly good user interface.

Among medium-power database programs, Forethought's FileMaker and Microsoft's File both work well. FileMaker is a little easier to learn and use, and it indexes everything for fast retrieval; but File can store pictures as a field, while FileMaker can include pictures only in a form. If you store many pictures, you will need a hard disk drive, since pictures eat up storage quickly.

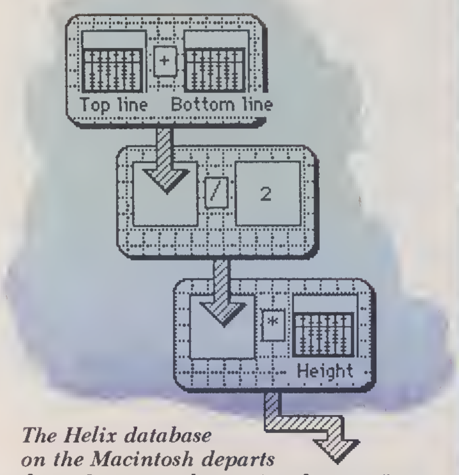
For the heavyweight databases, Omnis 3 from Organizational Software is the first to support network operation and features a particularly comprehensive set of tools for generating a custom database application using the Macintosh interface. Omnis does need more flexibility at its core, though; it permits no more than 60 characters in a field and does not store font information. Macintosh databases show far greater variety than those for the IBM PC, and Odesta's Helix is the most unusual one yet. Queries can be set up graphically by arranging icons with arrows in the manner of a flow diagram. Helix is not easy to learn, particularly for those accustomed to conventional databases, but if you overcome the initial hurdles, it offers a distinctive and potentially powerful way to get at data.

Other recommended programs for the Macintosh: SmartCom II from Hayes for communications, Fluent Fonts from Casady Co. for a varied font selection at a low price, and FONTastic from Altsys for editing fonts.

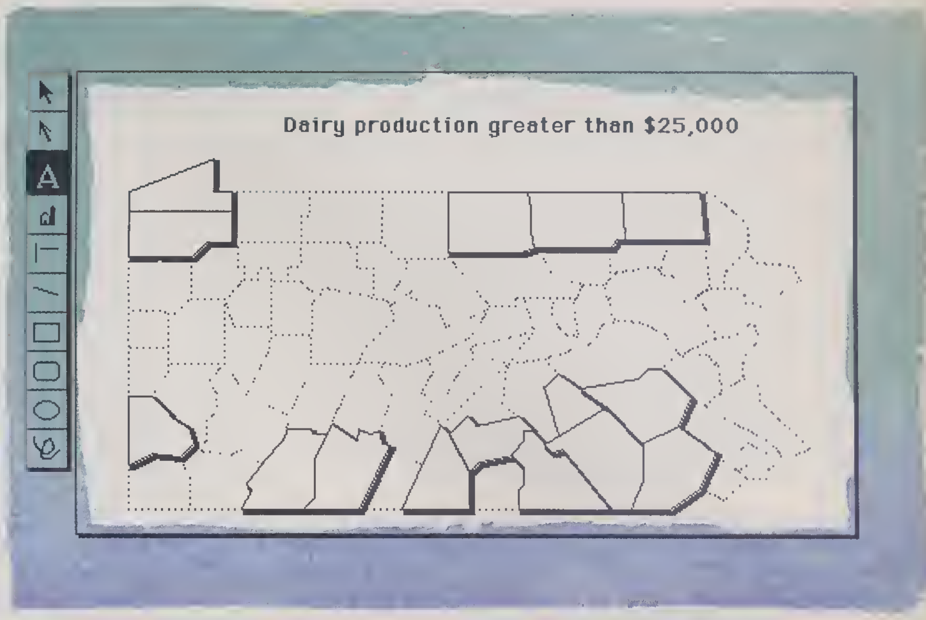
A major innovation in software is the advent of interactive communications, a type of program that will gain importance as networks and telecommunications grow. Such software lets two or more people at different locations work with the same data and see the same screen. Thus two managers across the continent can polish a memo together or brainstorm with a spreadsheet. On the Macintosh, SmartCom II from Hayes includes interactive graphics—what you draw on the screen with a mouse appears on the remote computer as well; that way, an architect and a builder might jointly decide on the best place to put a drain spout.

On the IBM PC, both cc:Share from PCC:Systems and Carbon Copy from Meridian Technology work with existing programs and perform their communications in the background. Both can transfer complete screen displays. In cc:Share's joint-running mode, two users load identical software packages and cc:Share runs the programs in tandem by updating both machines with the same instructions. One user at a time gives program commands, passing over a control "baton" to the other when finished. With Carbon Copy, the application program is loaded on a single machine, but a user at the remote computer can also issue commands.

Progress in the most fundamental type of software—operating systems—has been slow. Displacing MS-



The Helix database on the Macintosh departs from the text-and-equation format. Instead, you construct commands out of flow diagrams and icons; this example calculates the area of a trapezoid (add top and bottom lines, divide by two, and multiply by the height).



Instead of displaying simple text or business charts, the Filevision database on the Macintosh can show calculated results graphically. This agricultural database set up by Graham Bell shows results by highlighting counties in Pennsylvania that meet the selection criterion. For more information, you point at the county with the mouse and press the mouse button.

DOS and the Macintosh operating system will require software with exceptional capabilities. Although UNIX and its many derivatives have for years been proclaimed the operating system of the future—each year the future is postponed for another year—it is unlikely to become a major factor in microcomputing. Its two key strengths are software development tools and multiuser operation, neither of which is relevant to the way microcomputers are generally used. The development tools—now available on other operating systems—are of interest only to programmers, and the multiuser configurations common on minicomputers are unlikely to spread to micros.

UNIX does seem assured of several niche markets, particularly in computer-aided design and other scientific/technical applications, where there are some excellent software packages. These packages require computing power and large display screens that current mainstream microcomputers cannot supply. UNIX will also be the hidden operating system in some file servers on networks. The file server will store and retrieve database information without the user ever seeing the formidable UNIX interface or even the many UNIX menu-driven shells. The databases available for UNIX are powerful only in their internal operations; successful operation requires a separate microcomputer program to cover up the many problems associated with the user interface.

The AT&T UNIX PC features a graphics-based shell for giving commands to the operating system. With current programs, once you get past the shell, you land in the world of UNIX software. Business programs for UNIX, mostly text-based, have not been aging gracefully; they generally work less effectively than the MS-DOS equivalents. New programs are appearing only gradually.

If in 1985 the software outstripped the capacity of the hardware, 1986 and 1987 should bring a reversal. New microcomputers will boast much faster computing, and improved operating systems will permit much more flexible operation. These new micros will equal and in some cases exceed the power of most minicomputers. Such power at our fingertips should break the hardware bottlenecks. Then, after the software developments of 1987 and 1988, we can start complaining about hardware limitations again.

Cary Lu is microcomputer editor of HIGH TECHNOLOGY.

Companies

Altsys, Box 865410, Plano, TX 75086, (214) 596–4970
Ansa, 1301 Shoreway Rd., Suite 221, Belmont, CA 94002, (415) 595–4469
Borland International, 4585 Scotts Valley Dr., Scotts Valley, CA 95066, (408) 438–8400
Casady, Box 223779, Carmel, CA 93922, (408) 646–4660
Centram Systems, 2372 Ellsworth Ave., Berkeley, CA 94704, (415) 644–8244
Forethought, 1973 Landings Dr., Mountain View, CA 94043, (415) 961–4720
General Computer, 215 First St., Cambridge, MA 02142, (617) 492–5500
Hayden Software, 600 Suffolk St., Lowell, MA 01853, (617) 937–0200
Hayes, 705 Westech Dr., Norcross, GA 30092, (404) 449–8791
Hercules, 2550 Ninth St., Berkeley, CA 94710, (415) 540–6000
Innovative Data Design, 1975 Willow Pass Rd., Suite 380, Concord, CA 94520, (415) 680–6818
Javelin Software, 1 Kendall Sq., Bldg. 200, Cambridge, MA 02139, (617) 494–1400
Leading Edge, 225 Turnpike St., Canton, MA 02021, (617) 449–4655
Meridian Technology, 1101 Dove St., Suite 120, Newport, CA 92660, (714) 476–2224
Morrow Designs, 600 McCormick St., San Leandro, CA 94577, (415) 430–1970
Odesta, 3186 Doolittle Dr., Northbrook, IL 60062, (312) 498–5615
Organizational Software, 2655 Campus Dr., #150, San Mateo, CA 94403, (415) 571–0222
PCC:Systems, 480 California Ave., Suite 201, Palo Alto, CA 94306, (415) 321–0430
Symantec, 10201 Torre Ave., Cupertino, CA 95014, (408) 253–9600
Tangent Technologies, 5720 Peachtree Pkwy., Suite 100, Norcross, GA 30092, (404) 662–0366
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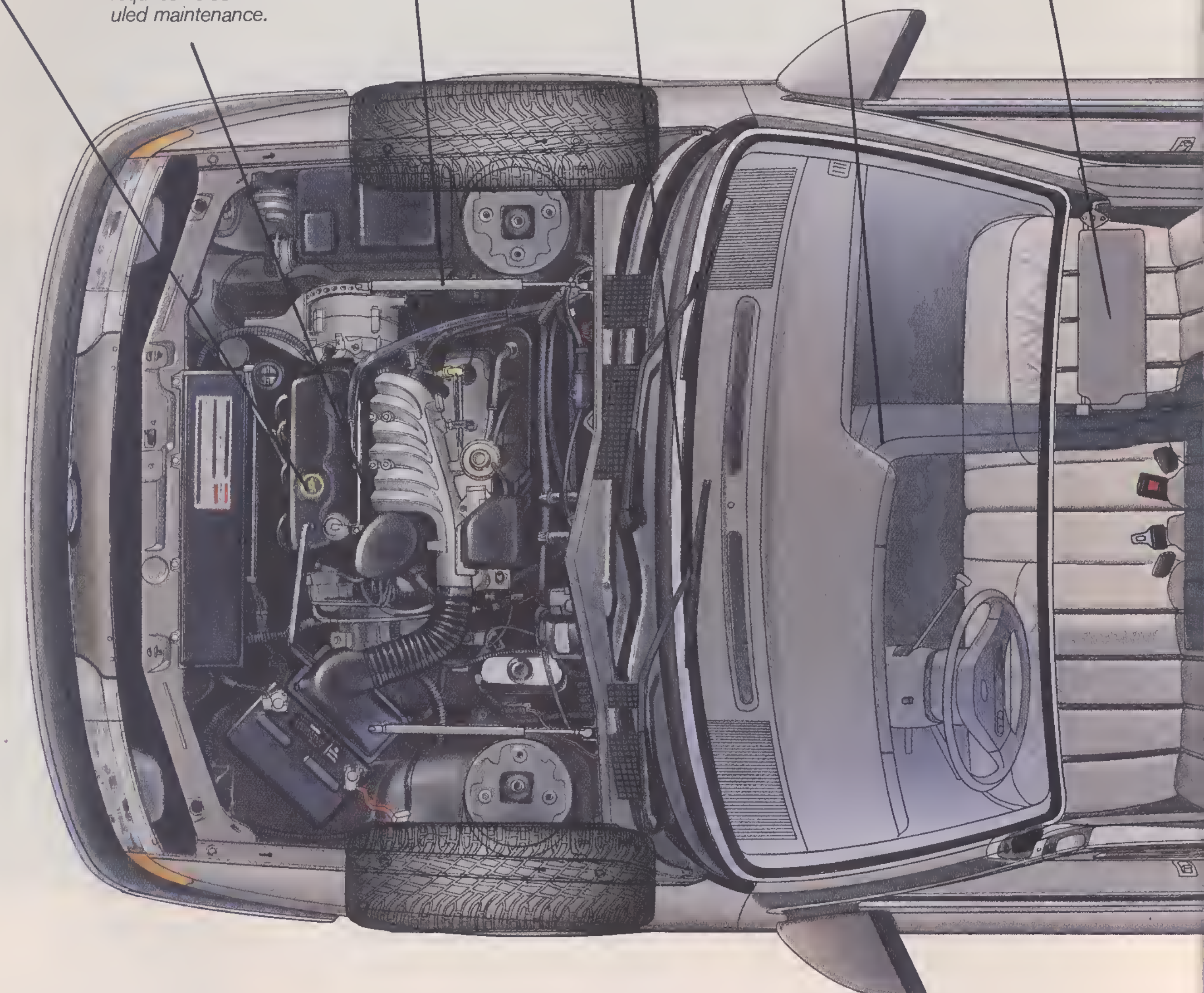

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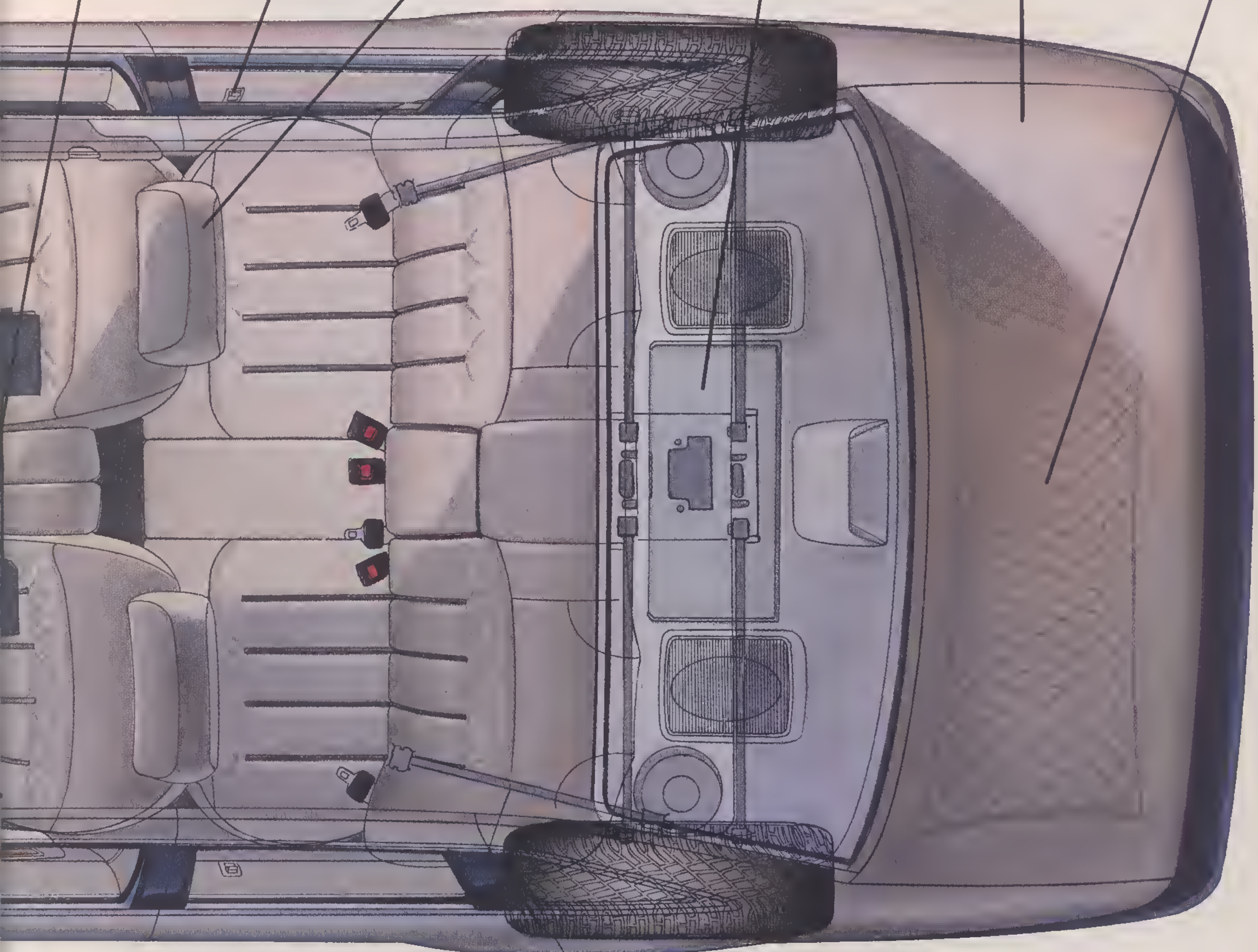

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BUSINESSES TAKE ROOT IN UNIVERSITY PARKS

Industrial centers near campuses promote sharing of resources and development of new firms

by Sarah Glazer

Relations between academia and industry have not traditionally been close. Academic scientists tended to shy away from influences that might taint the purity of their research aims, while corporate leaders were generally content to leave the theorists in their ivory towers. But that was before Stanford University turned its surrounding orchards into Silicon Valley—the world's "fertile crescent" of high tech entrepreneurship—and before sharp cuts in federal research funding (except for defense-related projects) made corporate support crucial. Today, links between universities and industry have strengthened considerably, to the point where over 40 schools, in cities from Orlando to Seattle, are trying to repeat Stanford's formula for success. These "research parks," real estate developments usually adjacent to campus, are intended to draw R&D companies into the university environment and to help nurture those that are already there. Some of the most successful so far are Forrestal Center at Princeton, with over 50 companies in residence; Research Triangle Park between the University of North Carolina, Duke, and North Carolina State, with over 40; University of Utah Research Park, with over 30; New Haven Science Park at Yale, with over 20; and, of course, Stanford Industrial Park, with 80.

The university's strongest motive for

ILLUSTRATION BY ROB COLVIN

developing industry on its doorstep is pure defensiveness, believes Chase Peterson, president of the University of Utah in Salt Lake City. Administrators have learned that they must "increase financial opportunities for faculty and students," he says, or risk losing their top science and engineering researchers to the corporate world. Peterson should know: "Two years ago, we lost the head of our toxicology department to Genentech in San Francisco."

Stanford, in fact, set up the prototype research park in 1951 to stem its own engineering brain drain, says Frank Morrow, a real estate consultant who was in charge of the park when he was Stanford's real estate director. "Frederick Terman—a professor who later became dean of the engineering school—wanted to stop the exodus of engineering grads to the East," says Morrow. With token support from the university, Terman convinced several former grad students who were starting their own companies—William Hewlett, David Packard, and the Varian brothers (Sigurd and Russell)—to set up shop in Palo Alto. Today, computer manufacturer Hewlett-Packard and instrument manufacturer Varian are two of the main reasons the Santa Clara Valley is a magnet for engineering talent from around the country and the world.

Most observers believe that a company's strongest incentive for locating in a university research park is the proximity to skilled researchers and to well-equipped labs. Being at Princeton's Forrestal Center "has turned out to be the greatest stroke of good fortune," says Marc Ostro, founder and chief science officer of Liposome, a biotechnology company. "We're right in the heart of the pharmaceutical industry and are two miles from the Princeton campus. We use research equipment there that we couldn't afford to buy."

Many universities in the industrial Northeast and Midwest are hoping that access to top-caliber research teams will counteract the high wage and tax rates that are driving local manufacturers toward sunnier climes. Such a rationale is behind a recently established research park at the Madison campus of the University of Wisconsin, which ranks itself as the third most heavily funded research university in the United States. "Taxes are high in Wisconsin, it snows in the winter, and other parts of the country can offer lower wages," says Robert Brennan, president of the Greater Madison Chamber of Commerce. "But we have a great grad school." It also has significant support from the state. Wayne McGown, assistant to the university's chancellor, observes that the state legislature passed a budget increase for the university this year—despite pressure to cut funding—because it recognized the school's importance to economic development.

Some states have enthusiastically supported parks for just this reason, both in industrial and in predominantly agricultural areas. New York helped fund several programs at Rensselaer Polytechnic Institute—in addition to its park—aimed at breathing new life into the area's manufacturing base. And North Carolina's state government was the driving force behind Research Triangle Park because it hoped to attract industry to a relatively undeveloped region.

From the R&D companies' point of view, locating near a university provides a steady opportunity to size up potential employees. Computer graphics company Evans & Sutherland, a tenant of the University of Utah Research Park, recruits aggressively for entry-level technical staff at the neighboring grad school, according to Susan Mickelsen, the firm's director of corporate relations. For companies, says Everett Rogers, an associate dean at the University of Southern California, "the chance to eye promising grad students and faculty" is one of the most worthwhile aspects of collaborative research.

But in some fields, such as artificial intelligence, university research departments are more than just recruiting grounds; they are the undeniable center of scientific activity. "When we were talking about where to locate," says Howard Schrob, technical director for Symbolics, a maker of AI-oriented computers, "I realized it was important to be close to MIT. If you want to know what's really going on in AI, that's where the seminars are." The company leased a building two blocks from the Cambridge, Mass., campus; given the local traffic and parking problems, says Schrob, "being even two or three miles away would have been too far."

Blueprints for research parks. The actual mechanics of setting up research parks have changed considerably since the 1950s and '60s, when entrepreneurs were usually content with space in old barracks buildings and garages. Standards have risen, and with some 40 parks underway nationwide, fledgling companies can be choosier. "The competition has gotten much stiffer," contends Mark L. Money, vice-chancellor of Texas A&M University. In contrast to the modest university investments for the first parks, he notes, "Arizona State is spending $15 million up front for roads, utilities, and landscaping—before commitment from any tenants—and Texas A&M will spend $6 million for site development before breaking ground for buildings."

Land itself can cost a bundle for schools that don't already own adjoining undeveloped acreage (as Stanford did in the 1950s). Princeton, for example, earmarked $27 million for land acquisition and improvements at the Forrestal Center site, according to Money. The problem is particularly acute for urban campuses, where undeveloped land is usually nonexistent and where expensive amenities such as high-rise parking lots are often necessary. In addition, others in the community may have their own agendas. MIT's differences with residential neighbors caused a delay of several years before its University Park could proceed. MIT finally agreed to include 100 new apartment units and several open grassy areas in its plan.

While most universities leave the specifics of site development and construction to real estate developers, almost all take part in selecting tenants. They usually stipulate that companies be oriented toward research or technology, a definition loose enough to admit, say, venture capital firms that fund high tech companies. Most parks seek tenants from many fields, but a few now in the planning stages focus on single technologies. A proposed park in Clemson, S.C., intends to admit only companies in the medical field, and another planned for San Antonio, Tex., expects to limit its tenants to biotechnology firms. Such projects, which aim to achieve a critical mass in a particular field, could be headed for trouble, according to Texas A&M's Money. "There just isn't a broad enough market right now," he says.

Regardless of scope, almost all current parks restrict their tenants' activities. Manufacturing and assembly is in most cases limited to small-scale operations, most often for making prototypes or devices directly linked to long-term research and development. In contrast, Stanford's park in 1951 was open to all "clean" industry—that is, companies that didn't belch black smoke—and included publishing houses and ordinary offices, says Morrow, its former director. The irony, he adds, is that some industries then considered clean, such as semiconductor manufacturing, have turned out to be major producers of hazardous waste.

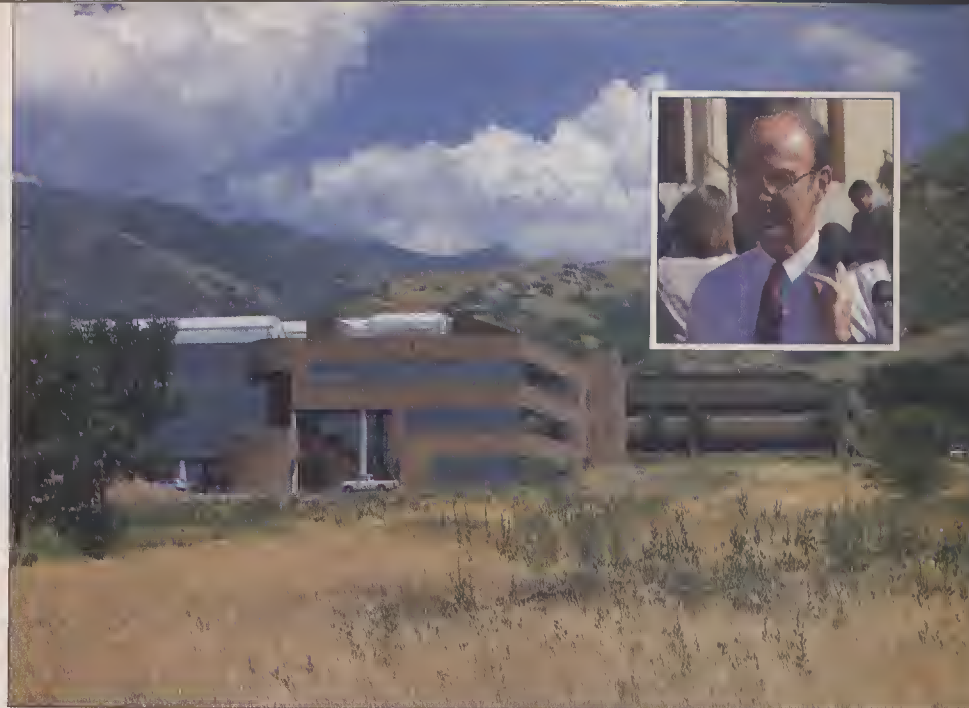
Most parks include buildings for both single and multiple tenants. In some cases a multitenant building is set up as a small-company "incubator" to help nurture young firms. For example, a recently opened incubator in London, the South Bank Technopark—one of many European developments much like those in the U.S.—gives its tenants bookkeeping services and access to an

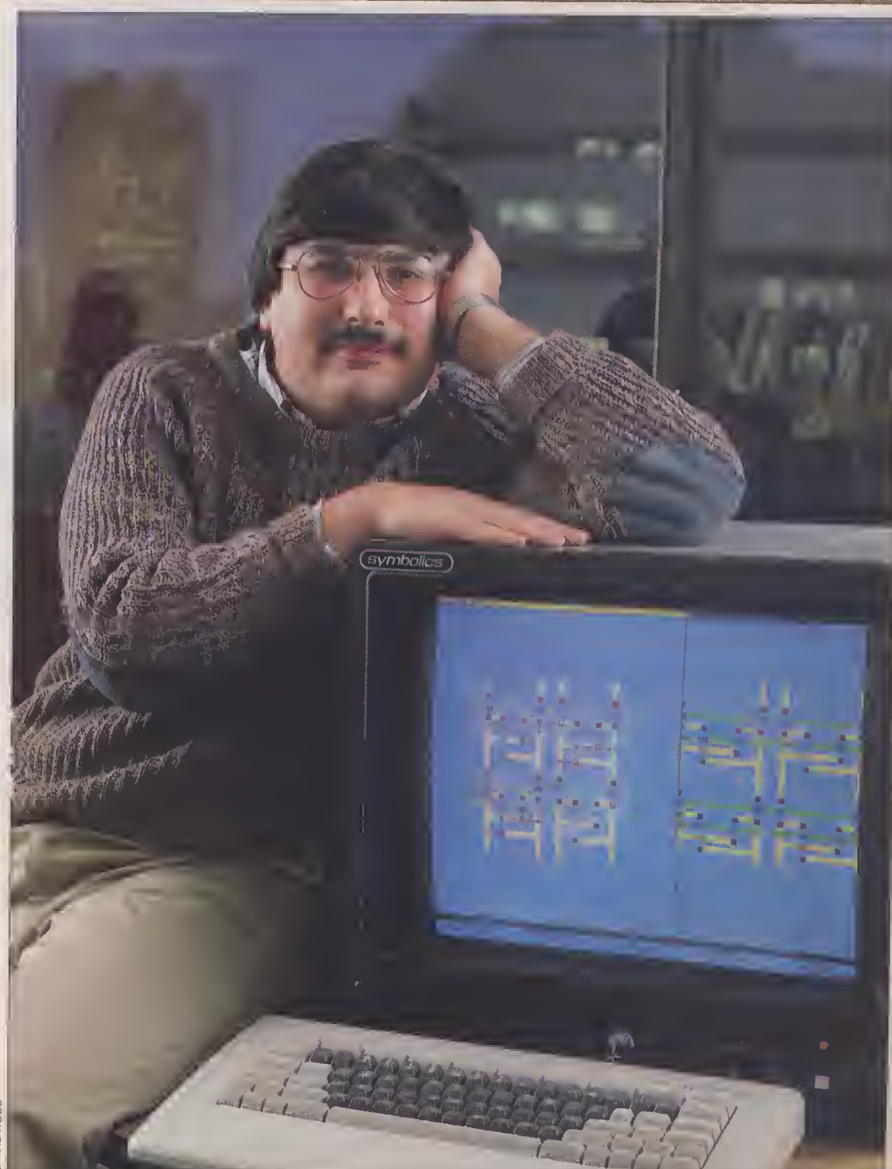
adjacent technical college's computer system and engineering labs. "We are attracting companies three to five years old, for the most part, that are growing but unable to afford expensive offices," says the park's director, Jeffe Jeffers. "Our aim is to keep companies here for a short time and then move them into custom property we hope to build."

Even if a company isn't in an incubator, being in a research park often gives it access to services available almost nowhere else. Since becoming a tenant in Yale's New Haven Science Park a year and a half ago, Impulse Engineering, a maker of high-energy power-conditioning systems for equipment such as lasers and CT scanners, has been using Yale's computer system and electron scanning microscope on a pay-per-use basis, says vice-president and cofounder Tony McNulty. The arrangement has helped the young firm immeasurably, he says. "When you're on a venture capital–funded budget, every penny counts." And Evans & Sutherland's Mickelsen says that when the company started in 1968—while its two founders were still professors at the University of Utah—its presence in the park enabled it "to piggyback on insurance and other benefits from the university."

In the case of the state-supported schools, such arrangements have sometimes come under criticism. Off-campus competitors of park tenants have charged that their taxes are helping subsidize favored companies. The intent of these publicly owned parks is to generate revenue for state and municipal coffers—both by stimulating economic growth and by giving the universities an independent source of income through the leases on their property. Yet most do offer their tenants unusual benefits, at least partly underwritten by other university facilities. "All we're doing," argues Utah's Peterson, "is building our own Rockefeller Center" (this valuable piece of Manhattan real estate was bequeathed to privately owned Columbia University). Wisconsin's McGown acknowledges that "building a long-term endowment for the future is only a recent concept in public universities." The implicit subsidy problem, and how these institutions can also function as real estate managers, must still be ironed out.

Cultivating home-grown firms. As a rule, research parks have been most successful in fostering local companies and especially in aiding entrepreneurs among the faculties and student bodies of their own schools. For some parks, the focus on local ventures is strictly pragmatic. "We have limited resources for competing with





RICHARD WOOD

Industrial parks near campuses may help stem the brain drain from academia, says the Univ. of Utah's Chase Peterson (top). But they also contribute to divided loyalties among faculty, says Symbolics' Howard Schrob, shown in his office overlooking MIT (bottom).

TECHNOLOGY RESEARCH PARKS
UNIVERSITY-AFFILIATED DEVELOPMENTS

Arizona State Univ. Research Park
Reginald Owens, Exec. Dir.
2105 Elliot Rd.
Tempe, AZ 85284 (602) 965–2105
ACRES 323
DATE EST. 1983 **TENANTS** 3

Engineering Research Ctr.
(Univ. of Arkansas) Neil Schmitt, Dean
College of Engineering, Univ. of Arkansas
Fayetteville, AR 72701 (501) 575–3054
ACRES 23
DATE EST. 1982 **TENANTS** 0

Stanford Industrial Park
Vera Murphy, Assoc. Dir.
Lands Management, Stanford Univ.
209 Hamilton Ave.
Palo Alto, CA 94301 (415) 326–7195
ACRES 660
DATE EST. 1951 **TENANTS** 80

Univ. of Connecticut–Storrs
James Makuch, Dir.
Admin. Services, Gulley Hall
352 Mansfield, Univ. of Connecticut
Storrs, CT 06268 (203) 486–2339
ACRES 390
DATE EST. 1982 **TENANTS** 0

New Haven Science Park
(Yale Univ.) Henry Chauncey, Jr., Pres.
Science Park Devel. Corp.
5 Science Park
New Haven, CT 06511 (203) 786–5000
ACRES 80
DATE EST. 1981 **TENANTS** 82

Univ. Research Park at Lewes
(Univ. of Delaware)
Robert D. Varrin, Coordinator for Research
Univ. of Delaware
Newark, DE 19716 (302) 451–2136
ACRES 100
DATE EST. 1979 **TENANTS** 0

Innovation Park
(Florida State Univ. & Florida A&M)
Fred Williams, Exec. Dir.
1673 W. Paul Birac Dr.
Tallahassee, FL 32304 (904) 576–8573
ACRES 208
DATE EST. 1979 **TENANTS** 2

Central Florida Research Park
(Univ. of Central Florida)
Patrick Vaughn, Marketing Dir.
11800 Research Pkwy.
Orlando, FL 32826 (305) 282–3944
ACRES 1400
DATE EST. 1981 **TENANTS** 14

Univ. of Florida Research & Technology Park
Donald Price, VP, Research
Progress Center, Grinter Hall
Univ. of Florida
Gainesville, FL 32611 (904) 392–4646
ACRES 2200
DATE EST. 1983 **TENANTS** 6

Advanced Technology Devel. Ctr.
(Georgia Tech) Donald Plummer, Mgr.
Research & Communications
430 Tenth St., NW
Atlanta, GA 30318 (404) 894–3575
ACRES 3
DATE EST. 1980 **TENANTS** 16

Evanston/Univ. Research Park
(Northwestern Univ.) Ronald Kysiak
Evanston Inventure, 1710 Orrinton Ave.
Evanston, IL 60201 (312) 864–9334
ACRES 26
DATE EST. 1985 **TENANTS** 0

Purdue Industrial Research Park
Winfield F. Hentschel, VP & Treasurer
Purdue Research Foundation
Hovde Hall
W. Lafayette, IN 47907 (317) 494–8641
ACRES 177
DATE EST. 1961 **TENANTS** 25

Northern Kentucky Univ. Foundation Research/Technology Park
Ralph A. Tesseneer
Northern Kentucky Univ. Foundation
Highland Heights, KY 41076
(606) 572–5126
ACRES 75
DATE EST. 1980 **TENANTS** 1

Maryland Science Technology Ctr.
(Univ. of Maryland) Robert Smith, Pres.
Univ. of Maryland Foundation
Univ. of Maryland
Adelphi, MD 20783 (301) 853–3700
ACRES 466
DATE EST. 1983 **TENANTS** 1

University Park
(Mass. Inst. of Technology)
Philip A. Trussell, MIT, Rm. 12-192
Cambridge, MA 02139 (617) 253–4304
ACRES 27
DATE EST. 1983 **TENANTS** 0

Geddes Center
(Eastern Mich. Univ & Univ of Mich.)
Kay Williams, Superior Township Clerk
3040 N. Prospect
Ypsilanti, MI 48197 (313) 482–6099
ACRES 508
DATE EST. 1985 **TENANTS** 0

Ann Arbor Technology Park
(Univ. of Michigan)
Barbara Davidson, Dir., Public Rel.
Wood & Co., 21C Ft. Evans Rd.
Leesburg, VA 22075 (703) 777–8137
ACRES 820
DATE EST. 1960 **TENANTS** 15

Dandini Research Park
(Univ. of Nevada) Albert Gold, VP
Desert Research Inst., Box 60220
Reno, NV 89506 (702) 673–7315
ACRES 470
DATE EST. 1984 **TENANTS** 0

Princeton Forrestal Ctr.
Eugene D. Biddle, Dir., Marketing
Princeton Forrestal Ctr. Admin.
Princeton Univ.
105 College Rd. East
Princeton, NJ 08540 (609) 452–7720
ACRES 1750
DATE EST. 1974 **TENANTS** 50

Univ. of New Mexico Research Park
Alan Prickett, Dir., Real Estate
Scholes Hall
Albuquerque, NM 87131 (505) 277–6465
ACRES 90
DATE EST. 1965 **TENANTS** 2

Rensselaer Technology Park
(Rensselaer Polytechnic Inst.)
Michael Wacholder, Acting Dir.
100 Jordan Rd.
Troy, NY 12180 (518) 283–7102
ACRES 1200
DATE EST. 1981 **TENANTS** 26

Research Triangle Park
(Univ of N. Carolina, Duke U., N. Carolina St.)
Robert E. Leak, Pres.
Research Triangle Foundation
Box 12255
Research Triangle Park, NC 27709
(919) 549–8181
ACRES 6551
DATE EST. 1959 **TENANTS** 47

University Research Park
(Univ. of North Carolina–Charlotte)
Rusty Goode, Pres.
Univ. of North Carolina–Charlotte
Charlotte, NC 28282 (704) 375–6220
ACRES 2800
DATE EST. 1966 **TENANTS** 11

University Research Complex
(Ohio State Univ.) Rick Finholt, Coord.
Univ. Research Complex
200 Sullivant Hall
Columbus, OH 43210 (614) 422–9250
ACRES 200
DATE EST. 1981 **TENANTS** 3

Miami Valley Research Park
(Wright State U., Univ. of Dayton, Sinclair Comm. College, Central State Univ.)
James W. McSwiney
Mead Corp., Courthouse Plaza
Dayton, OH 45401 (513) 222–6323
ACRES 1500
DATE EST. 1980 **TENANTS** 3

Swearingen Research Park
(Univ. of Oklahoma) John Sexton
Real Estate Devel. Office
Univ. of Oklahoma
1000 Asp Ave., Rm. 210
Norman, OK 73019 (405) 325–2138
ACRES 600
DATE EST. 1958 **TENANTS** 20

Univ. City Science Center
Charles D. Dilks, Senior VP
3624 Market St.
Philadelphia, PA 19104 (215) 387–2255
ACRES 16
DATE EST. 1964 **TENANTS** 80

Carolina Research Park
(Univ. of South Carolina–Columbia)
Bob Henderson, Dir.
South Carolina Research Authority
Box 12025
Columbia, SC 29211 (803) 799–4070
ACRES 580
DATE EST. 1983 **TENANTS** 1

Tennessee Technology Corridor
(Univ. of Tennessee) Jeff Deardorff
Tenn. Technology Foundation, Box 23184
Knoxville, TN 37933 (615) 966–2804
ACRES 2200
DATE EST. 1982 **TENANTS** 97

Texas A&M Univ. Research Park
Mark. L. Money, Vice Chancellor
Research Park, Texas A&M Univ.
College Station, TX 77843 (409) 845–7275
ACRES 434
DATE EST. 1984 **TENANTS** 0

Univ. of Utah Research Park
Charles Evans, Dir.
Research Park, 505 Water Way
Salt Lake City, UT 84108 (801) 581–8133
ACRES 320
DATE EST. 1970 **TENANTS** 51

Virginia Tech Corporate Research Ctr.
William Hargrave, Dir., Economic Devel.
220 Burruss Hall, Virginia Tech
Blacksburg, VA 24061 (703) 961–5751
ACRES 120
DATE EST. 1985 **TENANTS** 0

Washington State Univ. Research & Technology Park
John Schade, Dir.
Research Park, 432 French Admin. Bldg.
Pullman, WA 99164 (509) 335–5526
ACRES 158
DATE EST. 1982 **TENANTS** 0

Morgantown Industrial & Research Park
(W. Virginia Univ.) John Snider, Exec. VP
1000 Dupont Rd., Bldg. 510
Morgantown, WV 26505 (304) 292–9453
ACRES 670
DATE EST. 1983 **TENANTS** 8

University Research Park
(Univ. of Wisconsin–Madison)
Wayne McGown
Special Asst. to the Chancellor
946 WARF Bldg., 610 Walnut St.
Madison, WI 53705 (608) 262–3677
ACRES 217
DATE EST. 1982 **TENANTS** 2

The research parks listed here are either operating or under active development, although appropriating funds, gaining neighborhood approval, and completing construction has become a lengthy process for some. Another 10–20 parks are in early planning stages.

SOURCE: URBAN LAND INSTITUTE, WASH., DC

major U.S. centers like Boston and San Francisco," says Glenn Mitchell, senior officer for the research park development authority in Edmonton, Alberta. "Our efforts are going toward growing our own companies."

But for all universities, whether near high tech epicenters or far away, looking inward for the seeds of start-ups makes sense. Academics may need no more than official encouragement—or, at the very least, a lack of active discouragement—to launch an entrepreneurial career, contends Matthew Bullock, a director of Barclay's Bank (London) who helped develop the research park adjacent to Cambridge University. "Academics shouldn't be forced to choose between continuing an academic career and starting a very uncertain new enterprise."

But functioning with one foot in industry and the other in academia requires a good sense of balance, in both a practical and an ethical sense. "When people have dual allegiances, it's hard to keep them separated," says Symbolics' Schrob, who is himself a part-time lecturer at MIT's AI lab. They increase the likelihood that advisers will—perhaps unconsciously—steer their students into doing research that is commercially valuable but scientifically unexciting. "Most professors are not ripoff artists," Schrob stresses, but students can nonetheless get robbed of the chance to do more challenging research. His own solution to the dilemma is to pursue two distinct areas of research. "At Symbolics I do chip architecture, and at MIT I do AI," he says. But while the division reduces conflicts of interest, it also means he must spread himself pretty thin. "The practical consequence," he says, "is that I don't spend enough time doing AI to supervise students."

Universities nudging faculty towards business should take care not to go overboard, cautions Wisconsin's McGown. Because "pulling professors out of the classroom could be devastating," he says, time spent away from teaching duties should be worked out individually with the approval of a faculty member's entire department. Otherwise, professors who aren't involved in off-campus ventures may legitimately feel coerced into shouldering extra duties, while their colleagues get a shot at becoming rich and famous. The University of Utah's solution is to require professors whose outside work interferes with their academic duties to go onto part-time status. It also allots a portion of royalties from commercializing faculty research to the researcher's department. "The assumption," says Peterson, "is that they all contributed to give one person that extra time."

Texas A&M provided roads and utilities for its park, says vice-chancellor Mark L. Money (top); Yale's urban setting (bottom) made such costs largely unnecessary.

Interdepartmental jealousy can also be a problem, especially when faculty members feel that the university encourages some but not all of them to pursue commercial ventures. When faculty senates must vote on research parks, the proposals do not always win support from humanities and social science staffs, who are already painfully aware of enrollment trends toward majors in hard science, engineering, and business. Accommodating industry–university collaboration isn't easy. Says Peterson, "It does contaminate the ivory tower," and academics must learn to play by new rules.

The importance of location. Even though almost all parks are encouraging home-grown ventures, some universities have also managed to entice companies from other parts of the country. They are usually institutions that not only have top-

European schools get into the act

Anxious to trim their lingering high unemployment (and to shed their technologically dowdy images), many European countries are aggressively playing matchmaker between their top universities and growth-minded U.S. biotechnology companies. The Americans, meanwhile, are just as anxious to move into the European marketplace by producing and testing new products in what is widely regarded as a nimble, responsive regulatory setting.

The award for effort probably goes to Holland, where a $400 million private venture capital group in the Hague—Maatschappij voor Industriele Projecten, or MIP—has been thumping the virtues of Dutch workers and universities to American executives since 1982. "We were very impressed with the MIP," says Franklin Pass, chief executive officer of Molecular Genetics (Minnetonka, Minn.). "They're aggressive and upbeat, and have first-rate connections with the Dutch business community." Partly funded by the MIP, Molecular Genetics is now building a research and production site at Leiden University's bioscience park, where it will perform work in plant genetics and animal healthcare products.

The subsidiary will have no formal ties to the university (although Leiden professors will sit on the new company's scientific board). However, says Pass, "we knew right off that this would be the perfect environment for our kind of work." Besides the rich academic setting, Pass clearly sees Holland as the company's doorway to Western and Eastern European markets.

One of Molecular Genetics' neighbors at Leiden will be Centocor-Europe, a subsidiary of the Malvern, Penn., producer of monoclonal antibodies (specialized proteins used in disease diagnosis and treatment). Funded with $2.5 million from the MIP and slated for start-up in early 1986, the facility will conduct clinical research on monoclonals for imaging cancer cells in the body and for detecting heart disease. In the latter procedure, a proprietary antibody called antimyosin is hooked to a radioisotope and injected into the bloodstream. The protein attaches only to another protein, called myosin, which is released from the heart muscle during a coronary attack. A special camera is used to create a vivid portrait of the bound antibodies, thus identifying the location and extent of dead muscle.

Like Molecular Genetics, the company maintains a flexible relationship with the university, says Bruce Peacock, vice-president of finance. "But we're counting on a broad exchange of ideas and information," he says. "The university will make space and other resources available to us. In return, we will support several of its research programs and be an important employer for the students." Centocor has signed about a dozen such contracts with European researchers, several of them at Leiden.

But it was Scotland that pocketed what is reportedly one of the heftiest biotechnology investments ever made in Europe—the $40 million production facility planned near Edinburgh by Damon Biotech (Needham, Mass.), another leading U.S. monoclonals company. During the search for a site, president Nigel L. Webb met with several public and private venture groups in Holland, West Germany, and his native England. What finally hooked him, he says, was the enthusiasm and economic support offered by the Scottish Development Agency (Glasgow) and backed up by a group of European venture capitalists led by Advent Ltd.

Damon's relationships with local academics are still tentative, says senior vice-president Joseph F. Lovett, although professors from the area will probably sit on the scientific board of the new company (called Damon Biotech Ltd.). "We've known for a long time that there's top-notch medicine in that region, especially at the University of Edinburgh," says Lovett. "It was certainly one of the major factors in our decision."

The company holds exclusive patent rights to a cell encapsulation technique (called Encapcel) that reportedly yields much higher product densities than other culture methods. The Edinburgh facility will use Encapcel to make a variety of biological products beginning in early 1987, says Lovett—including monoclonals and a clot-dissolving protein called tissue plasminogen activator.

—H. Garrett DeYoung

caliber research departments but are located in areas with charms of their own. "The major cities are great resources, with the quality of life to hold talented people," says Jeffers at London's South Bank Technopark. Ostro of biotech start-up Liposome extols Princeton's resources when describing his company's tenure there. "Princeton is a great place to live, a stone's throw from two major metropolitan areas—New York and Philadelphia." It's also close to some of the company's potential customers, he adds, and within easy reach of several large airports.

Although universities in less settled regions tout the merits of a leisurely lifestyle, they do face competitive disadvantages. Compared with the Northeast and the West Coast, there's very little local financing for new companies. Madison, Wis., for instance, has no local venture capital firms, a deficiency that chamber of commerce president Brennan concedes has slowed economic development. In an effort to bring local entrepreneurs to the attention of out-of-town money, Madison recently held its second venture capital fair. And Salt Lake City, reportedly a tough place to find funding despite the university's aid to start-ups, recently saw the establishment of its first venture capital firm.

For Impulse Engineering, the wishes of its financial backers played a big part in its decision to set up in New Haven, reports VP McNulty. His partner, David Turnquist, formerly worked in the Boston area—the home of the company's venture capital backers—while McNulty worked in Stamford, not far from New Haven. "Boston is a very expensive place to start a business," says McNulty, "but the venture capitalists didn't want us to be too far away." Convenient transportation, a good supply of skilled technicians, and, of course, Yale resources made New Haven an ideal choice.

Most university parks probably can't hope to match the fast growth rate of Yale's New Haven Science Park, which has acquired more than 20 tenants since it opened in 1981, or that of the Cambridge Science Park, the research park connected with Cambridge University in England, which sprang up in a few short years with no university involvement other than its gift of land. The effort to cultivate high tech industry far from existing centers is a long, slow process. Research Triangle Park, for example, took 30 years to acquire its 40 tenants. "It took 20 years just to take off," says Rogers at USC. "The turning point didn't come until IBM started a big R&D center there."

Patience pays. One of the main prerequisites for a development's success is simply staying power, contends Texas A&M's Money. For most

A former test farm at the University of Wisconsin provided a nearby park site in otherwise crowded Madison.

universities, which lack the perfect combination of world-class research talent, the infrastructure of a nearby metropolis, and a thriving financial community, progress is painfully slow. "You can't really hurry things up," says Money, but intelligent management can improve the odds considerably. "The success of most university parks will depend on how well they are able to identify the university's strengths and market them."

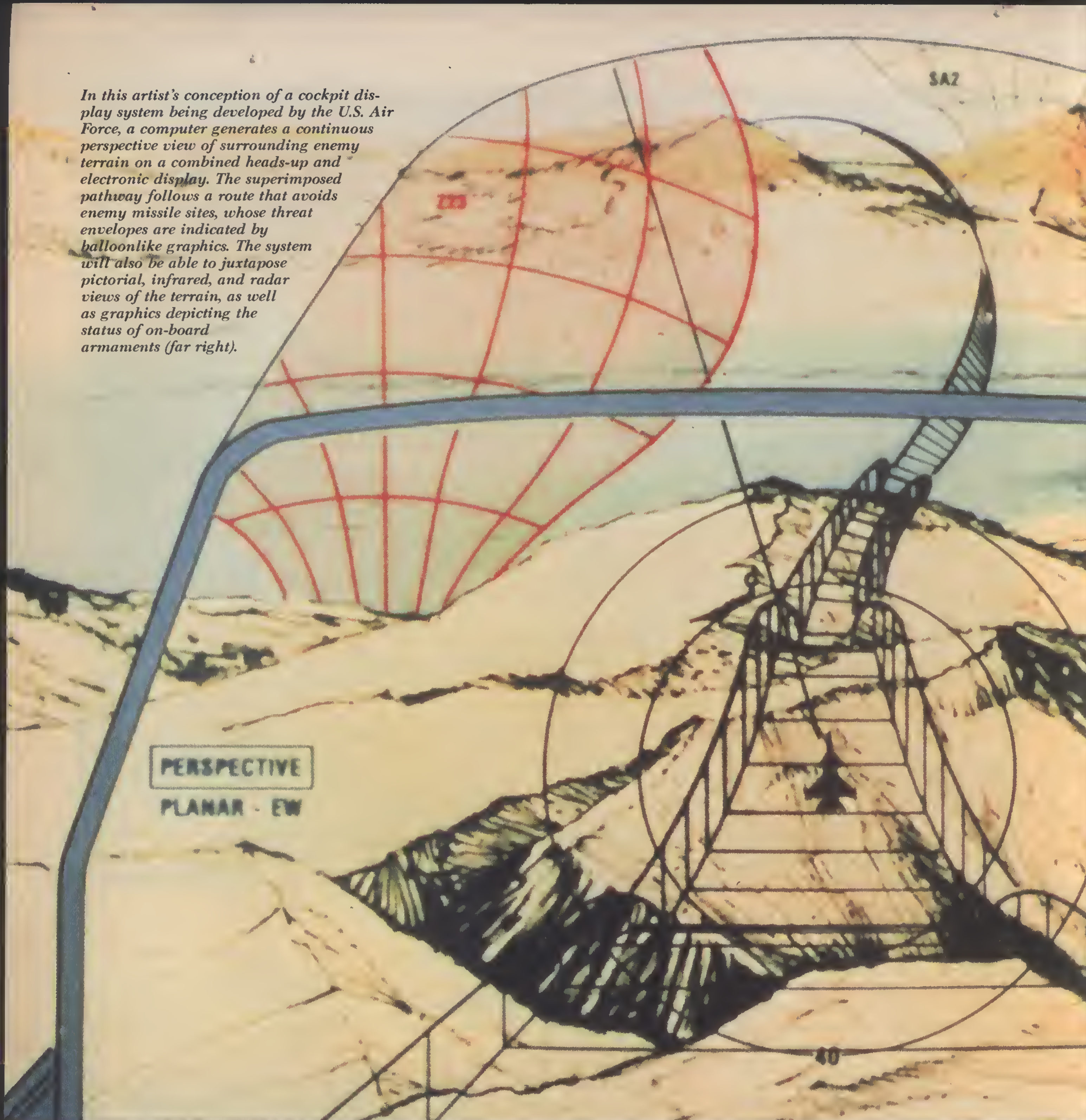
If they do succeed, universities may end up with tenants that, in their maturity, bear little resemblance to the young companies that once required such careful cultivation. The parks' success may also pose a new set of problems. Stanford's development, for instance, is turning into a corporate headquarters park, populated by established companies rather than start-ups. "New companies can't afford to come in," says Morrow, the park's former director, "and Stanford is now trying to figure out how to get them in there to nourish new research." Successful development can also inflate housing prices, as the Santa Clara Valley real estate market has so dramatically proved, making it difficult for either corporate or academic researchers—much less the valley's original residents—to live nearby.

Of course, there are also advantages for universities surrounded by established, prosperous companies—such as the availability of funds for fellowships, faculty chairs, and lab facilities. Some of the same Silicon Valley companies that were grateful to Stanford for the free use of lab space 30 years ago are funding ambitious research programs there today. In some cases, tenants offer help almost immediately. Start-up Liposome, with only 60 employees of its own, already funds two postdoctoral fellowships at Princeton.

But some visionaries foresee research parks not only fostering a diversity of relationships between universities and industry, but also drawing on the widest possible community and producing far-reaching effects. Jiro Tokuyama, a dean at the Nomura School of Advanced Management in Tokyo, hopes to see an internationally supported school set up in Japan or California for training managers and engineers. There, he says, "students could combine studying under an international faculty with getting practical industrial experience." Such a center would "establish a vast network of contacts for these students and encourage cooperation on an international level." □

Sarah Glazer is a senior editor of HIGH TECHNOLOGY.

For further information see **RESOURCES**, *p. 68.*



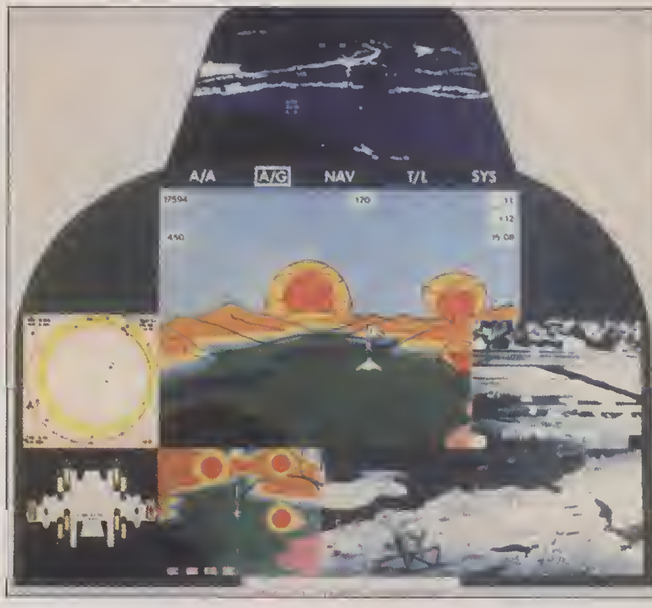
In this artist's conception of a cockpit display system being developed by the U.S. Air Force, a computer generates a continuous perspective view of surrounding enemy terrain on a combined heads-up and electronic display. The superimposed pathway follows a route that avoids enemy missile sites, whose threat envelopes are indicated by balloonlike graphics. The system will also be able to juxtapose pictorial, infrared, and radar views of the terrain, as well as graphics depicting the status of on-board armaments (far right).

As the U.S. aerospace industry prepares to develop a new generation of civilian and military aircraft, it is evaluating innovations for aircraft cockpits the likes of which have never been seen outside of science-fiction movies. The new cockpits, now under study in government and industry laboratories, are more akin to sleek electronic control rooms than to the flying boiler-rooms of today. They would include such features as:

• *Pictorial displays.* Present cockpit information systems give the pilot only a fragmentary picture of the outside world when flying at night or in the clouds. In contrast, sophisticated computer-graphics systems in future cockpits will use data from on-board sensors and digital terrain maps to give the pilot a realistic three-dimensional simulation of the scene around the aircraft.

• *Unified readouts and controls.* Today's cockpit employs a confusing array of mechanical dials and switches for displaying information and controlling on-board systems. Future cockpits will replace this jumble with a single, cockpitwide "electronic slateboard" that will serve as both a display medium and a data-entry panel. In contrast to present cockpits, where information is displayed whether it is needed or not, the computer-driven electronic slateboard will show only what is necessary for a particular phase of the flight.

• *Synthetic speech.* Whereas most of today's cockpit displays are monitored visually, the cockpit of the future will



BUILDING A BETTER COCKPIT

Electronic systems will make aircraft safer, more effective, and easier to fly

by Paul Kinnucan

use synthetic speech. Similarly, many systems will be speech-actuated. This will enable the pilot to direct his eyes and his hands to tasks of greatest priority.

• *Electronic flight and engine control.* Present aircraft are steered by means of pedals and a stick or steering column on the floor, both of which are connected to control surfaces by a complex mechanical system of rods and cables. In future planes, these controls will be replaced by a single small joystick mounted on the side of the cockpit, allowing an unobstructed view of the electronic slateboard. A computer system will translate the control stick's movements into electronic commands that change the aircraft's direction accordingly. The computer will also serve other control functions: It will automatically adjust the control surfaces to keep the aircraft stable in turbulent air, enforce limits in control-surface adjustments in order to prevent the pilot from accidentally stalling or spinning the aircraft, and—if the aircraft is damaged—employ a "self-repairing" procedure to reconfigure undamaged control surfaces.

• *Helmet-mounted displays.* In present military cockpits, critical flight and target information is displayed at eye level on a transparent screen (combiner) mounted on top of the pilot's console. In future aircraft, this heads-up display system will be miniaturized and moved to the pilot's helmet, thereby widening his field of view (because the combiner is closer to his eye), and enabling the

presentation of stereoscopic pictorial displays (through the use of a combiner for each eye).

• *Pilot's associates.* In present aircraft, the pilot acts as both a systems operator and a manager, coordinating the activities of automatic pilots, navigation systems, and radios. In future cockpits, systems operation will be handled by a computer—an intelligent flight management system that will not only carry out routine activities but also advise the pilot on how to react to the unexpected.

The Pentagon wants advanced cockpits to enable it to maintain parity with the Soviet Union, which has a substantial edge in sheer numbers of aircraft and pilots. Advanced cockpit technology is seen as a "force multiplier" that would enable U.S. fighters and helicopters to be manned by a single pilot—thereby offsetting the Soviet Union's advantage in personnel—and that would pack greater effectiveness into a single aircraft.

Another backer of advanced cockpit development is the Federal Aviation Administration (FAA), which has been funding development of advanced technologies by the National Aeronautics and Space Administration (NASA). The FAA sees advanced cockpits as enabling airliners and other civilian aircraft to realize a long-term goal: reduced dependence on the ground-based air-traffic control system. By reducing work load and increasing the pilot's situational awareness, advanced cockpits would enable civilian pilots to take over most of the responsibility for avoiding collisions in the air. This would make flying more like driving a car or boat, where the driver is responsible for avoiding collisions on the ground or sea.

The new cockpits will radically change the pilot's experience of flying. In current cockpits, for example, positional information is displayed on the cockpit panel by two instruments: an attitude/director indicator and a compass rose, both of which are two-dimensional displays. Altitude and horizontal and vertical speed are indicated by numeric readouts. Radar and infrared images are displayed on separate screens. To get a complete awareness of the situation outside the cockpit, the pilot must mentally integrate all this information—a problem comparable to forming a complete mental picture of a house from its blueprints.

In future cockpits, however, display systems will combine data from onboard sensors and digital maps to simulate the scene around the aircraft as well as provide three-dimensional flight director cues. Computer-generated pathways-in-the-sky will enable the pilot to verify instantly that the aircraft is on course, even along curved approaches to airports. The system will do the visualization for the pilot, enabling him to fly the aircraft in darkness or clouds with the same ease that he now flies in clear weather.

A prototype of such a pictorial display system is currently being developed by the Armstrong Aerospace Medical Research Laboratory at Wright-Patterson Air Force Base in Dayton, Ohio. Scheduled for flight tests next year, it will simulate the scene outside the aircraft as well as display images of communications, weapons, and navigation-control panels. The pilot will be able to interact with the display—for instance, to arm and fire a missile—by pointing and by issuing voice commands. Called the virtual cockpit, the system consists of a computer linked to two tiny CRTs mounted on the pilot's helmet. An optical system projects the CRTs' screen contents into the pilot's eyes to create a stereoscopic image. Sensors mounted on the helmet enable the computer to track the position of the pilot's head and thereby update the simulated scene accordingly.

The virtual cockpit will simulate the scene outside the aircraft as well as images of control panels.

Pictorial displays will simplify many tasks that have always been difficult for pilots. For example, the conventional flight director—a subsystem that graphically presents steering instructions—employs cross- or v-shaped bars to indicate the desired flight path. Ace Card, an avionics engineer with the Air Transport Avionics Division of Allied-Bendix in Fort Lauderdale, Fla., compares the problem of following current flight director commands to trying to steer a car by looking through a small window cut in the floorboard to keep it positioned over the center stripe in the road. The problem is that current flight director symbology gives no indication of changes in direction in the flight path.

For military pilots, the improved situational awareness made possible by infrared, radar, and pictorial displays will permit flight at low altitudes in bad weather and even in total darkness. This will allow pilots to use hills and valleys to shield their approach to battlefields in bad weather just as they now use them in good weather.

Prototypes of three-dimensional pictorial display systems—precursors to the virtual cockpit—are already being evaluated in ground-based flight simulators and in the air. For example, an advanced airliner cockpit being developed at NASA's Langley Research Center in Hampton, Va., uses a tunnel to indicate the path to be followed by the aircraft. The pilot attempts to steer the plane down this tunnel-in-the-sky in response to flight director steering commands.

The future cockpits will remove another worry: With current mechanical control systems, the pilot always has to be concerned about stalling or spinning the aircraft. "Flying is still like trying not to fall off a log," says Wolfgang Demisch, an aerospace analyst with the First Boston Corp. (New York). In contrast, tomorrow's smart electronic control systems will check to see that a pilot's steering command is within the safe limits of the aircraft—that it will not cause a stall or a tailspin, rip the wings off, or make the pilot black out.

Some aircraft currently in operational use already employ fly-by-wire (electronic) flight control systems. Notable examples are the General Dynamics F-16 fighter and the Concorde supersonic transport. In addition, many subsonic airliners employ fly-by-wire systems to control flaps, slats, and other secondary control systems. The Airbus 320 airliner now being developed by Airbus Industrie in Toulouse, France, will use such a system to control all surfaces but the rudder when it takes to the air in 1987. Thanks to the system's maneuver limitation feature, pilots will "not be able to stall or roll the Airbus 320," says Bernard Ziegler, engineering vice-president of Airbus Industrie.

Similarly, future engine control systems will not permit the pilot to exceed the engine's operating parameters. With current control systems, the pilot of a jet-powered aircraft must constantly be aware of the plane's altitude, angle of attack, and speed when pulling back on the throttle; exceeding the thresholds on any of these parameters could stall the engine. In the new electronic engine control systems, this becomes a nonproblem: These parameters are automatically assessed, and the engines produce only as much thrust as is safe—both for the plane and for the pilot.

But flight control systems that would prevent the pilot from demanding more force from the aircraft than his body can withstand might not be popular with pilots, according to Col. Albert Picarillo, program manager for the U.S. Air Force's proposed advanced tactical fighter (ATF). The problem is that pilots vary in their tolerance to maneuvering forces according to their physical condition and the amount of flying they have done recently. In combat,

The U.S. Air Force's virtual cockpit system will employ two tiny CRTs and associated optics on the pilot's helmet to generate a stereoscopic view of enemy terrain.

Electronic flight instruments take over the cockpit

The largest and most visible segment of the avionics market is that of electronic flight displays, which are rapidly changing the appearance of aircraft cockpits. The traditional cockpit uses an array of electromechanical dials to display such parameters as speed, direction, altitude, and fuel supply. The Electronic Flight Instrument System (EFIS), however, can display all this information on only a few cathode-ray tubes (CRTs). The reduction in instrumentation clutter may help to improve pilots' efficiency and performance.

The market for electronic flight displays is currently over $100 million annually, according to Forecast Associates (Newtown, Conn.), an aerospace market research firm. Military sales predominate; some form of EFIS with at least two CRTs is used on all frontline tactical fighters. Revenues from electronic cockpits should climb to over $1 billion by 1991, not only because of installations on new U.S. and European fighters expected to be in production by that time, but also because of growth in commercial aviation applications and the retrofitting of older military aircraft.

"Within the next five years, electronic flight displays will replace conventional instruments in most new commercial and business aircraft. This is a highly competitive market, and we do not intend to finish second."

Derek Van Dyke
Market Representative
Sperry Flight Systems

Three companies have taken an early lead in the market. Sperry Flight Systems (Glendale, Ariz.) has captured a large portion of the military segment: Each F-15 fighter, for example, uses three Sperry CRTs. The company is also involved in commercial applications, having recently won a $2 million contract to supply eight displays for NASA's Boeing 737 Transport Systems Research Vehicle, which is designed to explore innovations in information displays. Bendix Aerospace (Fort Lauderdale, Fla.), a division of Allied Corp., entered the civilian market following a $35 million research and development program it initiated in 1978. The Collins Air Transport Division of Rockwell International (Cedar Rapids, Ia.) markets one EFIS and is currently developing new systems for Airbus Industrie's advanced A320 passenger transport and Boeing's successor to the 767. Both will be highly automated aircraft, with cockpits that look more like offices than the traditional flight deck.

An electronic display system does not come cheap. A typical EFIS for commercial aircraft applications costs about $120,000, including four color-display screens, a microprocessor, associated software, and symbol generators. Even a single-screen display targeted by Sperry at the low end of the commercial market starts at $55,000.

Despite these high costs, demand for electronic flight instruments is increasing because they permit a reduction in the size of the flight crew. The McDonnell Douglas F-4 Phantom, for example, was one of the first modern fighters to use advanced, complex weapons systems, but a second crewmember, referred to as the GIB ("guy in back"), was needed to interpret the additional instrumentation. The EFIS, by providing the pilot with all necessary data on a portable television screen, makes possible a single-pilot fighter like the F-15. It also renders the aircraft less expensive to build and fly; the life-support systems and controls for a second crewmember would add about three meters to the fuselage, 300 kilograms to the weight, and $3 million to the cost of the aircraft, excluding the need for a larger, more expensive engine. Similarly, new commercial airliners can eliminate the flight engineer—the third crewmember on the flight deck, whose salary, benefits, and training can cost over $200,000 a year—by condensing aircraft engine and systems data onto a single set of EFIS screens.

Improvements in the software used to generate EFIS displays are also expanding the niche market for electronic instrumentation in helicopters. For example, the Air Force's Nighthawk rescue helicopter, due to enter the market in 1986, will be equipped with four CRTs—two in front of each crewmember—combining flight and aircraft performance data with topographic map displays. "With their ability to read and store information from charts, electronic map displays in the cockpit make the job of low-level navigation a lot easier," says Gene Mahacek, manager of systems marketing at Collins.

CRTs are not the last word in EFIS technology, since they require up to 14 inches of space behind the instrument panel. Research in flat-panel systems for use in aircraft and a variety of other applications is being carried out by such aerospace giants as Boeing Electronics (Seattle), Hughes Aircraft (Culver City, Cal.), and General Electric (Wilmington, Mass.), as well as by electronics companies such as Interstate Electronics (Anaheim, Cal.), Miltope (Melville, N.Y.), SAI Technology (San Diego), and Great Britain's Plessey Electronics. However, "this is an area in which the Japanese electronics industry is far ahead of the U.S.," says Bill Johnston, assistant director of market research at Sperry's Transport Division.

"Electronic flight instruments can cost 45% less than traditional electromechanical cockpit displays in commercial aircraft. This savings will mean higher profits for airlines and possibly lower fares for passengers."

Gene Mahacek, Manager
Systems Marketing
Collins Air Transport Division
Rockwell International

"By 1990, electronic cockpits will be increasingly based on flat-panel displays, which take up less than a quarter of the space needed for a CRT," says Johnston. And Forecast Associates estimates that by the mid-1990s, demand for flat-panel units will exceed the demand for CRT displays. ***—Jeff Richmond***

BENDIX

Airliners are taking the first step toward the electronic cockpit of the future by replacing electromechanical instruments with CRT displays. The conventional dials still remaining for backup will eventually disappear.

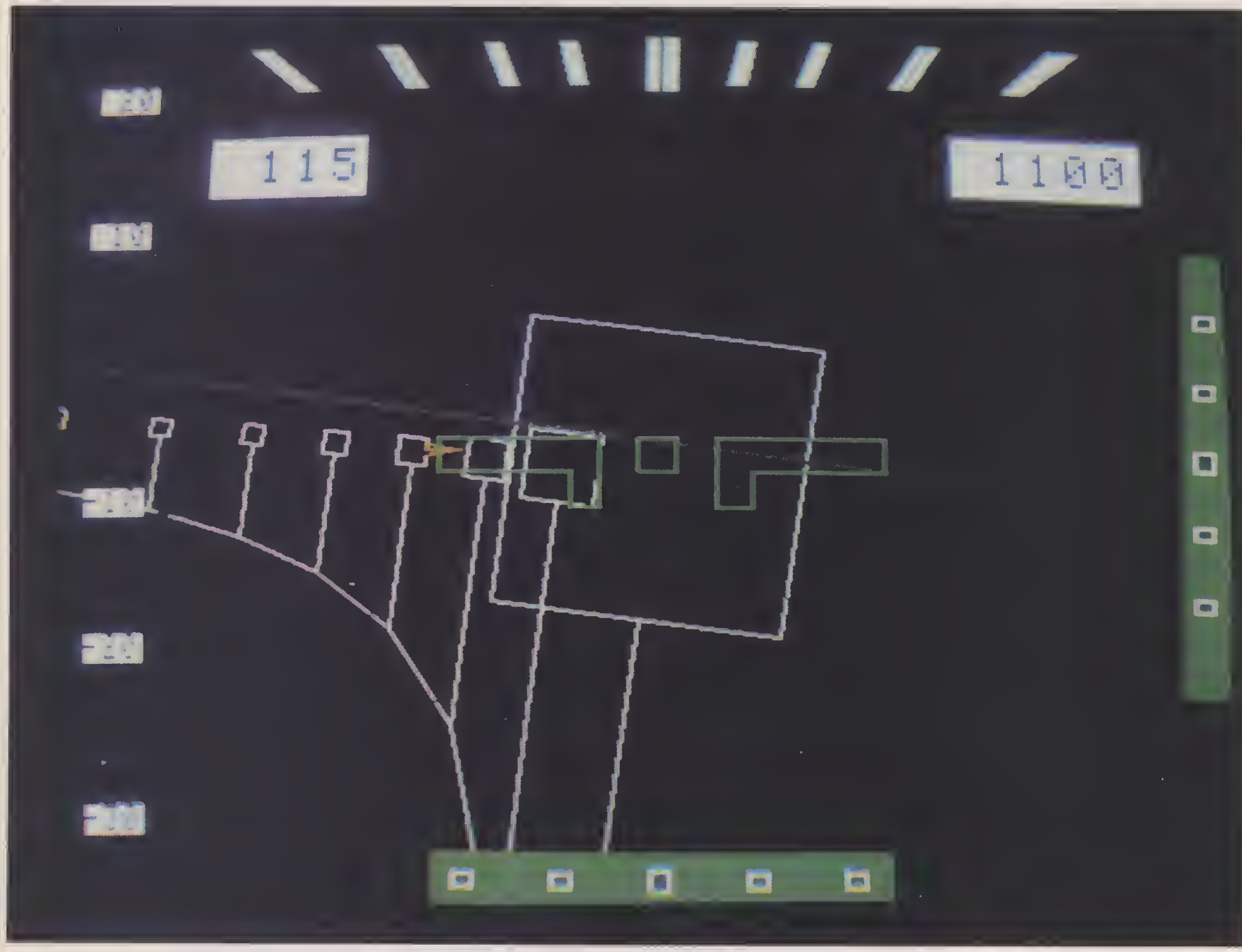
moreover, pilots may prefer the risk of losing consciousness to certain destruction by a missile. As a result, says Picarillo, Air Force planners have suggested that the maneuver limitation feature include a "peacetime" switch that would disconnect it.

Present flight control systems are static—they respond in the same way throughout the flight envelope. By contrast, future flight control systems will have variable response, depending on the flight regime, which will improve the pilot's control. For example, an experimental digital fly-by-wire system being tested on the AFTI/F-16 fighter (developed by General Dynamics for the Air Force, the Navy, and NASA) is programmed to give the best responses in four different modes: normal, air-to-ground gun attacks, air-to-air gun attacks, and bombing attacks. "With a push of a button, you can reprogram the system to give the best response for a task," says Frank R. Swortzel, deputy program manager for the AFTI/F-16. For example, small stick movements produce a greater change in the attitude of the aircraft in the air-to-air gun mode than in other modes. Tests have shown that the variable response improves the pilot's ability to maintain the aircraft pointed at a target, he adds.

The electronic flight controls will also improve performance by allowing unstable designs. For example, they will allow an aircraft's center of gravity to be located forward of the wing's center of lift; that way, the plane's horizontal stabilizers can balance the wing's lift by exerting an upward force instead of a downward force (as in a conventional aircraft). This will result in unusual maneuverabilty as well as reduced drag and hence better fuel economy. The use of aerodynamically unstable designs is currently a matter of controversy in the industry, however, because they could not be controlled if the flight control system failed.

The flight control system of the future will constantly monitor itself for malfunctions caused by internal failures or battle damage. If a subsystem fails, the self-repairing flight control system will automatically reconfigure itself to employ undamaged portions, and will advise the pilot on whether the mission should be continued. A self-repairing system could be simpler than current systems, because it would reduce the need for redundancy.

The Air Force's Aeronautical Systems Division at Wright-Patterson AFB recently demonstrated the benefits of self-repair using a laboratory aircraft equipped with a simple self-repairing fly-by-wire control system developed by General Electric (Binghamton, N.Y.). The system, called a flight control mixer, uses the total in-flight simulator (TIFS) aircraft to determine if flight control surfaces are healthy enough to take actions directed by the pilot. If not, the mixer decides which surfaces to move to achieve the desired aircraft response. The system's operation is "transparent" to the pilot, according to Capt. Michael Masi, TIFS program manager. When a control surface fails, says Masi, the system resorts to other surfaces so quickly that the pilot is not even aware of the failure. The Air Force plans to use a remotely piloted vehicle this year to test the system's performance when control surfaces are physically damaged.



NASA

In future airliners, pathways in the sky will simplify the problem of landing aircraft in darkness or bad weather.

In military aircraft, automation will help to improve performance. For example, future fighters will have an automatic attack system that can fly the aircraft toward a target at low altitude (maneuvering to avoid hills and other obstacles), execute a pop-up or toss bombing maneuver, and release bombs at the correct point—all without pilot intervention. The automatic systems will be able to deliver bombs from curved approaches—a procedure that a pilot could not do accurately—enabling the aircraft to avoid flying over the target where it would be vulnerable to ground defenses.

The systems will also be able to engage in aerial gunnery attacks against aircraft, including head-on and oblique shots that are next to impossible for a human pilot to make, according to Swortzel. The AFTI/F-16 program at Wright-Patterson AFB is currently flight-testing a prototype of such a system, called the Automatic Maneuvering Attack System (AMAS). At a Mach 2 closing rate, "you have to get off a shot before the pilot can even pick up the target," says Swartzel. Once the shot has been fired, he says, the automatic attack system will maneuver to avoid a head-on collision.

The ultimate addition to the cockpit of the future will be the pilot's associate, which will embody much of the knowledge that is gained through flying experience or is locked away in engineering, operations, and piloting manuals. These expert systems, containing the knowledge and experience of human specialists encoded as rules, will infer solutions to problems that would take too long for a pilot to solve or for which there are insufficient data. To save the pilot from having to enter a lot of information about a situation, pilot's associates will be linked directly to sensors. Thus, when a problem arises, the system will be ready with a proposed solution.

In combat, for example, the pilot's associate will be able to suggest which of multiple targets should be hit, or to evaluate which of several potential threats is the most dangerous. When an engine or other system malfunctions, the pilot's associate will be able to use the expertise of the best engineers to diagnose the problem and suggest remedies instantly.

Development of such systems is just now getting under way in various research laboratories. At NASA Langley, for example, researchers are developing a diagnostic expert for a turbofan engine of the kind that powers airliners. A far more sophisticated system is now in the early stages of development by the Defense Advanced Research Projects Agency. This system would be a collection of cooperating expert systems—each specializing in some aspect of aircraft operation such as troubleshooting, emergency procedures, flight planning, cockpit systems management, and (in the case of combat aircraft) battle management. The U.S. Air Force is serving as program manager for the pilot's associate project, but the actual development will be done by outside contractors. □

Paul Kinnucan is a senior editor of HIGH TECHNOLOGY.

For further information see **RESOURCES**, *p.* 68.

DIGITAL TAPES CHALLENGE COMPACT DISCS

Cassette formats with CD fidelity offer recording ability and 24-hour play

For some time now, Japan's giants of consumer electronics have been hard at work on systems for home digital audio tape (DAT) decks—products to provide the recording capability that compact disc (CD) players lack. The extremely low distortion and very long recording times possible with DAT make the new decks appealing to the serious audio consumer. But what is holding back progress is a lack of agreement on standards: As in the videocassette field, there are two possible recording techniques and a variety of potential recording media, including the half-inch and 8-mm tapes now competing in the VCR market.

The first DAT recorders actually came to market ahead of the compact disc as adapters for videocassette recorders, taking advantage of the VCR's long-playing format. The adapter, hooked up to a VCR, takes an analog audio signal, samples it digitally, and then formats the resulting bit stream to look like a conventional video signal, which is then fed into the VCR. These adapters, offered by Kodak, Sony, and Sansui among others, work well but add $500 or more to the price of a VCR. In addition, the resulting systems are large and clumsy compared with conventional audio decks, and the cassettes are bigger.

Consequently, the Electronic Industries Association of Japan (EIAJ) tried to develop standards for integrated digital audio tape recorders that would combine the performance of the best two-piece systems with the convenience of traditional audio cassette decks. From the beginning, however, there were deep divisions within the ranks. Most manufacturers wanted to base the new machines on existing VCR technology, using a pair of heads mounted on a spinning drum to record the digital signals diagonally across the width of the moving tape. To approach the compactness of conventional cassettes, the tape would need to be half to a quarter as wide as consumer videotape. The data density would thus be exceedingly high, but the basic design could be achieved simply by miniaturizing existing systems.

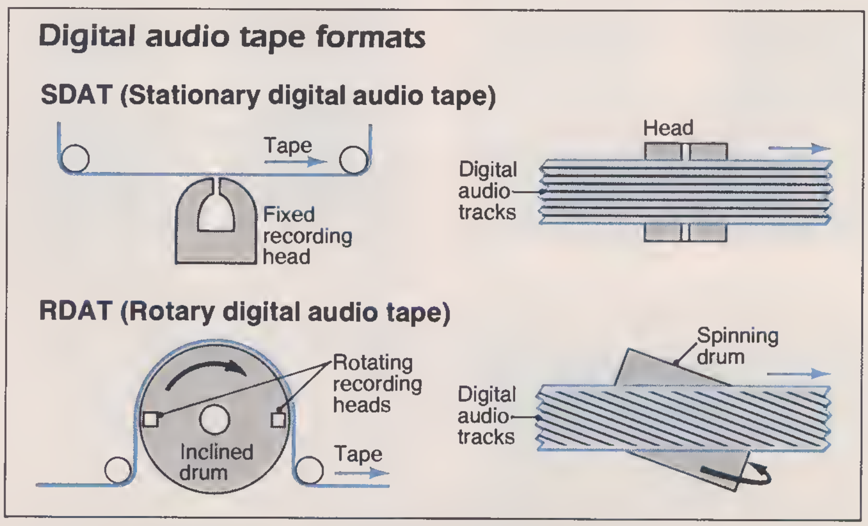
by Michael Riggs

The alternative was to use a fixed head that would record multiple tracks down the length of the tape—similar to conventional analog audio cassette decks. Although this technique is essentially simpler and can yield a more compact design, the equipment is harder to manufacture. The proposed stationary-head schemes use eight or more tracks crammed onto eighth-inch-wide tape. That means tight tolerances for the heads—as well as for the tape transport, which keeps the tape running true relative to the heads. In addition, the individual head gaps (the gaps between the magnets' poles) must be exceedingly small to handle the very high frequencies required. Such thin-film heads are hard to make and call for tape surfaces much smoother than those currently available.

Unable to settle the differences, the EIAJ decided to issue two standards: one for stationary-head digital audio tape (SDAT) and one for rotary-head (RDAT). The latter standard, issued in August 1985, calls for a tape cartridge slightly smaller than a normal audio cassette and capable of two hours of play. The metal-particle tape is recorded across its full width and therefore plays in one direction only. The digital encoding format is basically the same as for the compact disc: 16-bit linear pulse-code modulation (PCM), which provides a dynamic range of more than 90 decibels with very low distortion and no flutter.

The RDAT standard calls for a 48-kilohertz sampling rate, instead of the 44.1 kHz used for CDs. This extends the system's bandwidth into the ultrasonic range (up to almost 24 kHz). The reason for the change—which has no audible consequences—is to prevent direct digital copying of compact discs and thereby discourage piracy. Copying is still possible, but the CD's signal must be converted to analog and then reconverted to digital, adding a small amount of noise to the dubbed tape.

Two optional sampling rates are permitted. One provides a 32-kHz rate for discrete four-channel (quadraphonic) recording; for ordinary stereo this rate can double the maximum recording time to four hours. In either case the response will be flat only to about 15 kHz (the half octave given up is inaudible to most adults and typically contains virtually no information). The second option permits playback-only



Above: Recording technique for rotary digital audio tape (RDAT) uses an angled drum with two heads, as in a VCR, to record serial audio data diagonally across the tape (left). Top: Stationary method (SDAT) has multiple tracks to record audio in parallel along the length of the tape.

DAVE HANNUM

at 44.1 kHz, so record companies can produce digital cassettes from their CD master tapes; to prevent direct copying of CDs, recording will not be possible in this mode. The first RDAT models are expected to appear this year and will cost around $1000.

Although an SDAT standard will undoubtedly come, it will probably fall by the wayside. As a result of the technical problems yet to be solved, stationary-head machines will take longer to develop than RDAT decks and will cost perhaps a third more to manufacture. Thus the approach has few adherents. But this does not mean that the RDAT standard will duplicate the spectacular growth of the compact disc. Within the RDAT camp there is not yet a consensus on the type of cassette to be used. And although the RDAT standard envisages a new cassette similar in size to a conventional audio tape, an alternative has appeared in the form of the 8-millimeter videocassette.

The 8-mm (roughly quarter-inch) videocassette standard already includes an optional digitally encoded stereo soundtrack. Last summer, Sony (Park Ridge, N.J.), Pioneer (Long Beach, Cal.), and Kodak (Rochester, N.Y.) announced home 8-mm VCRs that support this option not only for video soundtracks but also for straight audio recording. When used as video recorders, these machines have maximum running times of two hours (standard play) or four hours (long play); the digital audio is recorded on a track that takes up a sixth of each pass of the rotating heads across the tape. But in audio-only, the deck can use the entire width of the tape to record as many as six two-hour stereo tracks on a single cassette, for a total playing time of 12 hours. Some machines also permit audio-only in the long-play mode, extending playing time to 24 hours. Tape cartridges for this format, which use special metal-particle or metal-evaporated formulations, are about twice as thick as an ordinary audio cassette but are otherwise comparable in size.

Although 8 mm was originally envisioned primarily as a camcorder medium, the addition of a slower tape speed and stereo digital audio would seem to pose a major threat both to DAT machines and to the bulkier half-inch videocassette formats. Indeed, Sony may have added the audio-only mode to its first 8-mm Beta-format videocassette deck to give it a market edge over the more deeply entrenched VHS units.

However, there are some performance limitations with 8 mm. The digital audio is encoded not in the 16-bit PCM format used by RDAT and CDs but in an 8-bit PCM format, which has a maximum unaided dynamic range of only about 48 decibels. A compander (a noise reduction system that compresses the signal in recording and expands it in playback) increases this range to over 80 decibels—more than adequate for home recording and better than an analog deck, but still not as good as RDAT. And the system's 31.5-kHz sampling rate restricts its high-frequency bandwidth to about 15 kHz. This barely affects fidelity, but audiophiles accustomed to 20 Hz to 20 kHz may perceive it as a deficiency.

The system's video performance is more problematic. The best 8-mm VCRs are just attaining the picture quality provided by standard half-inch machines at the same time that enhanced Beta and VHS systems, such as Super Beta and VHS High Quality, are becoming available. These new half-inch decks yield noticeably better pictures than earlier models. And though the audio performance of these recorders may not be up to that of the 8-mm models, they carry a more inviting price: as little as $800, versus well over $1000 for 8 mm. It remains to be seen whether the convenience of smaller videocassettes and a single deck for both audio and video is enough to woo buyers away from the performance advantages of dedicated digital audio recorders and half-inch VCRs.

Consumer dissatisfaction with LPs opened the way to acceptance of the compact disc. DAT will not have that advantage; analog audio cassettes are convenient and durable, and they command twice the market that LPs do.

DAT will compete mainly on performance and recording time, but consumers may find they can satisfy their needs with conventional analog equipment, thereby maintaining compatibility with the existing universe of analog cassettes and recorders. So DAT faces some of the same problems competing with analog audio cassettes as 8 mm does with VHS. Both may find it difficult to push aside firmly rooted media, especially since they will be competing with each other. □

Michael Riggs is a senior editor of High Fidelity *magazine.*

TALKING INSTEAD OF TYPING

Computers are gaining the ability to recognize and respond to voices

Speaking directly to a computer has long been dreamed of as an alternative to typing on a keyboard. But only very recently have products begun to appear that come close to realizing the dream of computers with the ability to identify and respond to verbal instructions. Analysts are already predicting that voice recognition technology will be a multibillion-dollar market by the mid-1990s, as voice input becomes the rule rather than the exception for entering text and commands into computers.

Millions of pages of office correspondence are created in the U.S. every year, much of it through the inefficient process of dictation-typing-revision. A voice input system would let information producers (typically, executives unable or unwilling to use a keyboard) bypass the middleman (the secretary), and turn their thoughts immediately into clean hard copy or machine-readable data. This potential gain in efficiency is motivating many companies to pursue intensive R&D on voice-activated typewriters (VATs).

While a useful VAT is still several years away, voice recognizers are showing up in less demanding applications where vocabularies of only a few hundred words are adequate. Employees at United Parcel Service, for example, use a voice-recognition terminal to enter routing information, which frees their hands to sort packages. Max Factor uses voice input to process orders, and employees at Blue Cross/Blue Shield of Massachusetts use it to speed up processing of claim forms.

In these systems, the computer is unaware that the commands are coming from a voice recognizer and not a keyboard. Such transparency avoids the need to rewrite software, thus

by Joseph J. Lazzaro

keeping down costs. "Voice technology is going to make electronic mail, messaging, and computer communications that much more user-friendly," says Bud Benton, director of voice and data systems at Wang Laboratories (Lowell, Mass.).

In telephone ordering and messaging systems, voice recognition can be a cost-effective way to give remote users access to a database or voice-mail network. The central facilities are simple to set up, requiring only a telephone and a voice recognition/synthesis circuit card installed in the office's computer. Anyone can telephone a computer so equipped and use voice commands to send or receive data. With such a "ten-cent workstation," says Benton, "you can use any phone to interact with your office computer when you're on the road."

Voice recognition devices gather sound waves, remove unwanted noises, and compare the incoming signal against a pattern (template) stored in memory. These templates are created at the factory or by the user. If the incoming sound closely approximates the template, then the word is recognized. If the sound is not similar enough to any stored template, then the system fails to recognize it; alternatively, the sound may be distorted and cause the system to correlate the word with the wrong template.

Virtually all commercial voice devices suffer from two important limitations. One is speaker-dependency; the system recognizes only the voice of the person with whom it has been trained. Speaker-independent operation—in which anyone's voice can be recognized, without prior training on the system—is sometimes offered for a few words, such as *yes*, *no*, and the numbers 0 to 9. But because multiple voice patterns are stored for each word in the speaker-independent vocabulary, this capability is a voracious consumer of memory.

A second constraint is that words must be spoken individually, instead of in a normal stream. The recognizer uses the periods of dead air to determine when one word stops and another starts; without the silences, it would be lost. While adequate for dictating short command words or phrases, such discrete-utterance units are generally considered unsuitable for VATs.

One of the most ambitious voice recognition systems comes from a start-up, Kurzweil Applied Intelligence (Waltham, Mass.). The company is the latest high tech entrepreneurial effort of Raymond Kurzweil, who earlier founded one company that makes text-reading machines and another that makes electronic musical keyboards capable of emulating an orchestra (HIGH TECHNOLOGY, Feb. 1985, p. 26).

Last fall Kurzweil began shipping the KVS-3000, which the company claims has a speaker-dependent vocabulary of 1000 words and the ability to interface transparently with almost any personal computer or mainframe. Kurzweil is touting the KVS as a forerunner to a more flexible system called the Kurzweil Voice Writer (KVW), a 15,000-word VAT that is also intended to be compatible with the IBM PC and other popular business computers and software.

The KVW will be an "adaptive speaker-dependent system," says Richard Goldhor, Kurzweil's director of software development, which means that the system will continue to collect data about the user's voice and speech habits even after the initial training session has been completed. It will thus become increasingly customized to the speaker, and accuracy should continue to increase over the time a person uses

TOM BLOOM

the system, eventually exceeding 95%, according to Goldhor.

In addition to matching sound patterns, the KVW will try to anticipate the next word in a sentence; linguistic analysis of a sentence will tell what part of speech (noun, verb, adjective, etc.) to expect. Although Kurzweil hopes to bring out the KVW this year, significant improvements are still needed. Speed, for example, must be increased from the present pace of two minutes per word to something approaching real time. Implementation of a new architecture that will cut recognition time to an average of 250 milliseconds "is nearly complete," said Goldhor late last fall. "The custom VLSI circuits are working and fully tested."

Another large-vocabulary (5000-word) voice recognizer is promised for later this year by Speech Systems (Tarzana, Cal.). Unlike Kurzweil, Speech Systems is not testing the waters first with a limited-capability machine. The company's VoiceLine will "combine statistics and artificial intelligence" to yield an accuracy of 95%, says president William Meisel, a former professor of electrical engineering at the University of Southern California who wrote an early textbook on pattern recognition. So far, the company has demonstrated recognition of "hundreds" of words, says Meisel, but only at about one-seventh the speed needed for real-time dictation.

Despite its considerable R&D in the field, IBM has yet to announce a commercial VAT. However, the company has demonstrated an experimental 5000-word system at its Thomas J. Watson research center (Yorktown Heights, N.Y.). The experimental system achieves an accuracy of 95% for its vocabulary of common office terms.

Like Kurzweil's planned KVW, the IBM machine tries to anticipate the next word. But IBM takes a statistical rather than linguistic approach. Once the system identifies a few words, it computes the probability of a given word coming next, using as a reference guide some 25 million words of office correspondence that it has previously analyzed. The system is limited to discrete words and must be retrained for each new speaker. IBM is trying to shrink the present mainframe-based system into a box that could be connected to a PC, but no such product is imminent.

IBM did introduce a more limited voice recognition product last fall, though. Using technology licensed from Dragon Systems (Newton, Mass.), the unit has a 64-word vocabulary and can be upgraded in 64-word increments by sacrificing response time. The system can be used to enter commands and data for any software that runs on the MS-DOS operating system.

Probably the largest single supplier so far of voice recognition hardware has been Votan (Fremont, Cal.), which makes a voice input board for the IBM PC as well as several stand-alone units for voice mail and telemarketing, and for input to IBM mainframe computers. Votan says its products use proprietary software to recognize vocabularies of several hundred words in continuous speech, without the pauses that most systems require to determine when a new word begins.

Votan recently agreed to supply voice recognition boards to Sperry (Blue Bell, Pa.) for Sperry's line of personal computers. The computers will thus be able to receive telephone calls, handle two-way messages, and accept voice input of data. The Votan card is transparent to most Sperry software, so the keyboard can be totally bypassed without reprogramming.

As computing power and memory become cheaper, it will become cost-effective to make voice recognition systems that are much more versatile than today's breed. Less expensive, higher-capacity memory chips will store enough variations of each word to allow speaker-independent operation for thousands of words. Similarly, expected cost reductions in logic circuitry should make feasible the enormously complex processing needed for continuous speech recognition in a large-vocabulary system—where the system essentially must assume at every instant that a new word might be starting, and procede to search for a match. The consensus in the field, however, is that the large-vocabulary, speaker-independent, continuous-speech recognizer needed for a voice-activated typewriter will not appear until the mid-1990s. □

Joseph J. Lazzaro, of Revere, Mass., is a computer consultant specializing in speech input/output systems.

PLANT MAINTENANCE ENTERS THE COMPUTER AGE

New software combats the rising price of inefficiency

Plant managers are turning to a variety of software packages to cut soaring mainte nance costs. For example, some programs allow operators to predict equipment failure.

Think of plant maintenance and the first image that comes to mind is a grimy, run-down shed tucked behind the building, even though the factory floor itself may be full of shiny robots and automated handling systems. But all of that may be changing, thanks to personal computers, minicomputers, and a growing list of maintenance-management software (MMS) packages for handling plant maintenance records, scheduling, and cost accounting. With menu-driven screens and powerful sorting algorithms, MMS systems specify what work should be done, when, and how much it should cost. Although such software packages are still relatively new, vendors are already preparing upgraded products (for large-scale project management, for example) using bar-code recognition and optical disc storage.

The development of such software is being driven by two forces—the growth of so-called vertical, or specialized, software markets, and the skyrocketing costs of maintenance in business and industry. "Ten to fifteen years ago, maintenance accounted for less than 1% of the operating budgets of most manufacturers," says Mark Goldstein, a West Boylston, Mass., maintenance consultant. "Today it constitutes 6–11%, and shows no sign of slowing down." Software vendors claim that a well-designed MMS system can cut labor costs for maintenance by 20% or more, and inventory costs by 10–15%.

"The cost of maintenance is only part of the picture," says Adrian Salee, principal at Emerson Consultants (New York). "A larger part is the cost of lost production and broken equipment caused by poor maintenance." And with the rise of the vaunted "factory of the future," he adds, maintenance will become even more important: "As production becomes more and more automated, maintenance workers are the only ones sure to remain. And if they don't do their job right, production is stopped."

At its heart, MMS is a specially adapted database-management software package; indeed, a few such systems are written in the assembly language of Ashton-Tate's dBase II, with predefined templates for maintenance functions. In this evolution, software suppliers are adapting horizontal (general-use) software to vertical applications, which market research firms like InfoCorp (Cupertino, Cal.) forecast will grow from a 26% share of today's $3 billion PC software market to 41% of 1990's $7.8 billion market.

MMS packages generally sell for $5000–$80,000; the price usually includes installation and several days of operator training. Some customers buy an MMS package and adapt it to their needs themselves, but many others prefer to hire a third-party consulting firm to adapt the program for them.

The typical maintenance department is virtually a self-contained business, with the factory its sole customer. The "business" maintains a parts inventory, as well as general laborers and specialized craftsmen; its "product" is increased on-time plant production through work-order scheduling, parts inventory, and cost control. Some MMS systems perform only one of these functions; others perform several, in a manner similar to integrated software packages such as Framework or Symphony.

Historically, work-order scheduling has been performed by a manager who collects a list of required maintenance tasks from the plant foreman (in addition to the routine maintenance required by most machines). The manager must then determine priorities, assign workers to each job, and estimate the duration of each task. The result has often been a blizzard of paperwork that must be collated and manually logged into the plant's operations records.

Computerization allows the maintenance manager to keep all records in magnetic memory, and to keep an automatic count of work orders in progress. Most work-order scheduling MMS modules also contain arithmetic subprograms that can calculate the manpower required for each job, so overtime can be scheduled in advance. In addition, some MMS packages permit the user to enter special instructions, safety precautions, and other information that can be printed onto the work order.

MMS can also simplify inventory records. Even in a small factory, the num-

by Nicholas Basta

ber of spare parts and tools can reach into the thousands; just locating the parts can become an excessively time-consuming chore. By computerizing inventory data, parts are automatically located, counted, and reordered when supplies fall to a predetermined point. Some MMS systems go even further by combining the rate of inventory consumption with anticipated lead times, then using this information to print out new purchase orders.

MMS cost-analysis options cover a broad range, with capabilities depending largely on whether labor and inventory data are included in the analysis. Some systems simply perform standardized, spreadsheet-like sums of items of similar or identical cost; others allow the manager to call up the specifications for a particular piece of equipment and thus compare the price and features of, say, a standard machine drill versus a new laser cutter. Some MMS systems provide information on the cost of operating certain types of equipment, or on the productivity of the maintenance staff. A few MMS programs can relay such data to the corporate mainframe for integration into total production costs.

In addition to these three basic components, a variety of MMS options are available:

• Tracking mean time between failure (MTBF), for example, is an increasingly popular method for analyzing equipment reliability. By automatically tracking this function on each piece of equipment, an MMS system can alert the user to declining performance, or out-of-line costs.

• Life-cycle costing adds initial equipment capital costs, maintenance costs, and the price of energy or raw materials needed to run the equipment. The result is the machine's lifetime expense. Such analyses are popular with vendors of very expensive equipment that promises longer life or lower operating costs. Life-cycle costing allows the user to confirm these selling points and thus cement buyer-seller relationships.

• True preventive maintenance implies the total elimination of unscheduled equipment shutdowns. While such results are rare in real life, computerizing previous maintenance records helps plant managers carry out preventive maintenance in a much more rigorous fashion. In addition, the warranties on many types of equipment require maintenance at regular intervals—for example, lubrication of bearings. MMS programs help keep

RAY ELLIS

Skilled maintenance workers are "the only ones sure to remain" in the highly automated plants of the future, says consultant Adrian Salee.

these procedures on schedule, and some systems contain an "exception reporting" option to alert the user when scheduled maintenance has not been performed.

New technology is being combined with MMS to make preventive maintenance more scientific. Vibration-analysis or acoustic devices, for example, are increasingly used to monitor equipment such as rotating machinery to uncover malfunctions before they shut down the machine. In vibration analysis, sensors are mounted on rotating parts to record the frequency of vibration. An electronic spectrum analyzer then plots a chart of the equipment's vibration "signature," which changes markedly just before failure. These signals can be compared over time and the results integrated with the MMS program. One software vendor, Entek Scientific (Cincinnati), offers a family of programs that run on Hewlett-Packard micros to perform this monitoring.

Debate continues to rage over how much computer power is needed for plant maintenance. There are currently about 50 micro-based vendors, estimates Emerson Consultants, and about 30 mini- or mainframe-based vendors. The fastest growth is in the

micro domain, and many vendors with large-computer software are producing scaled-down versions of their products for use on micros. Most micro systems require around 256 kilobytes of on-line memory and a 10–20-megabyte hard disk.

"With all the modules we provide for our system, we can handle maintenance departments of up to 200 workers," says Patrick Gehl, president of JB Systems (Woodland Hills, Cal.). The company's Mainsaver system is now in use at about 70 locations, and when fully implemented can handle several terminals run by one IBM PC. Other industry estimates put the efficiency cutoff at around 150 workers and 500–1000 pieces of equipment on a factory floor; data-storage capacity for tens of thousands of spare parts must also be allotted.

Maintenance consultant (and former IBMer) Goldstein claims that many of today's micro programs are already heading for obsolescence and that a larger computer is needed to handle the data needs of a large maintenance department. "Many maintenance departments have annual budgets in the tens and hundreds of millions of dollars," he says. "If that were an independent business, would you expect to run it on a micro?" But some observers point out that one primary reason for the failure of the mainframe-based MMS systems of the past is that the maintenance workers felt they had little control; if nothing else, using a relatively inexpensive desktop micro puts them in direct control of their MMS system.

The micro/mini debate has been studied closely at NUS Corp. (Gaithersburg, Md.), an engineering-consulting firm that offers its own MMS package. "We've found that running our software on an IBM 36 mini is 10 to 20 times faster than on an IBM PC or XT, and three to five times faster than on an AT," says Michael Martin, supervisor of maintenance systems. On the other hand, he says that IBM's new System/36 PC appears to be an ideal engine for a multiuser MMS system, in which several terminals would be driven by a single supermicro.

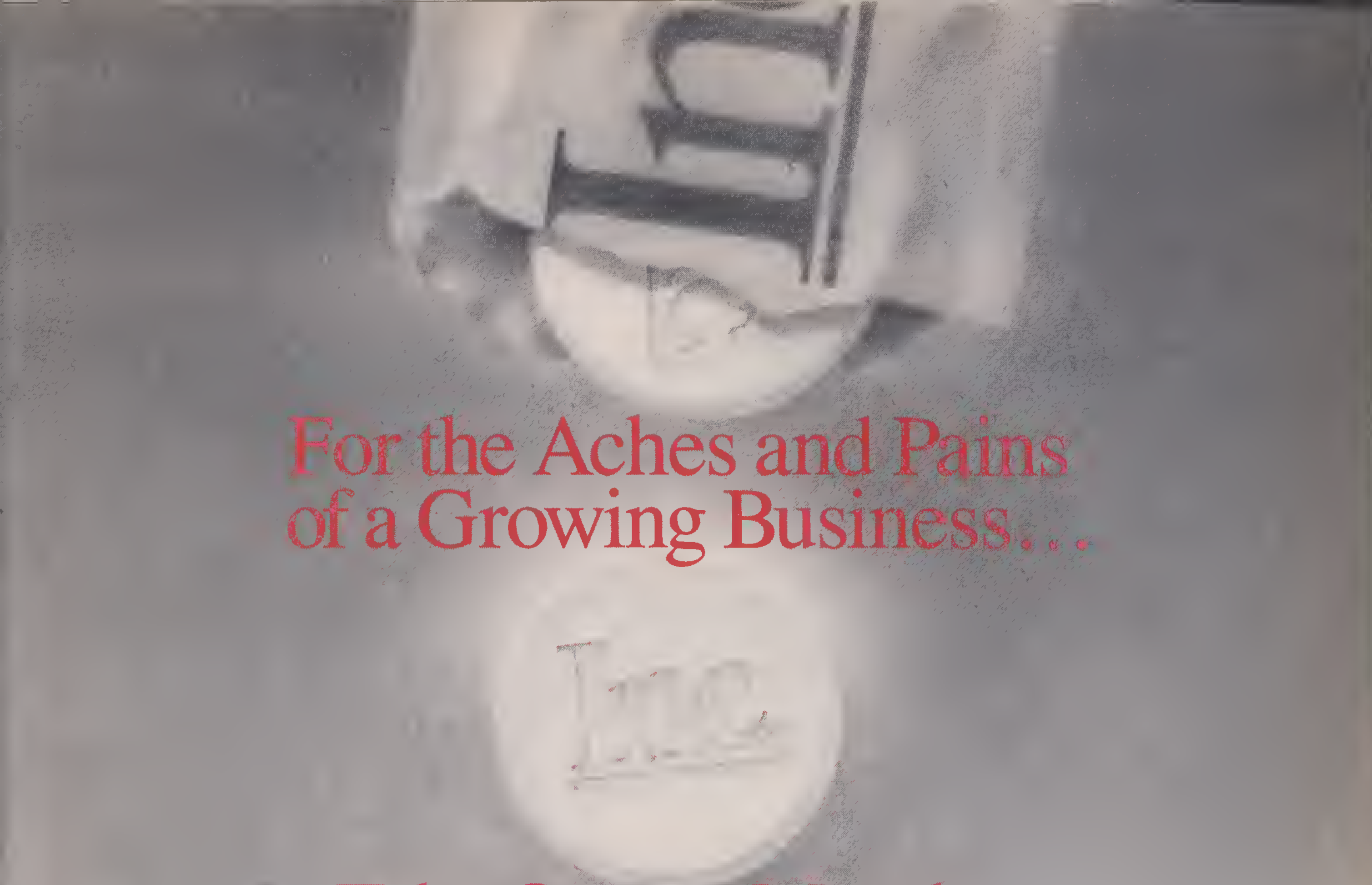
Today's MMS systems are being upgraded rapidly. New features that are likely to be added in the next several years include bar code–reading technology for inventory management and for speeding up work-order processing. This capability is already available in custom-designed programs, but does not appear to be offered by existing vendors.

Project management routines might also be added to MMS packages, says Michael Lawson, vice-president at Modern Management (Charlotte, N.C.), a maintenance consulting firm. Project management systems—the Harvard Project Manager, for example—are used to schedule complex jobs such as building construction. (See HIGH TECHNOLOGY, May 1985.) Other examples include plant turnaround—the month or so during which a factory shuts down for equipment overhaul—and new-plant start-ups. "Engineering companies are pretty good at keeping work on schedule during the initial construction phase," says Lawson. "But when a plant begins its start-up process, everyone suddenly reverts to handwritten work orders." The automation of record keeping for the start-up or turnaround would offer the same advantages as MMS systems do for day-to-day maintenance. At least one vendor, Turnaround Planning Services (Houston), already offers a $45,000 product called Turnaround Management.

JB Systems' Gehl adds optical-disc memory storage to the list of future product offerings. "Having optical disc–reading equipment would allow a maintenance department to put all its maintenance procedures, training programs, and supplier catalogs on a readily accessed medium," he says. Gehl also envisions a time when several hundred factories, all using the same MMS systems with optical discs, could pool their purchase-order data through a network that would allow high-volume purchases, and lower prices, for ordering spare parts. "We haven't decided yet whether we want to set up this service, or whether we would simply serve as the information conduit to other plant vendors," he says. "But we're looking closely at both options."

In view of the rising costs and importance of plant maintenance, it is logical that the function has come under intense scrutiny in U.S. factories. Nor is it surprising that the very term "plant maintenance" is beginning to yield to the more modern and descriptive phrase "asset management." As the price of industrial inefficiency continues to mount, MMS software is certain to fill a major role in tomorrow's factories. ☐

Nicholas Basta, trained as a chemical engineer, is a business and technology journalist in New York.



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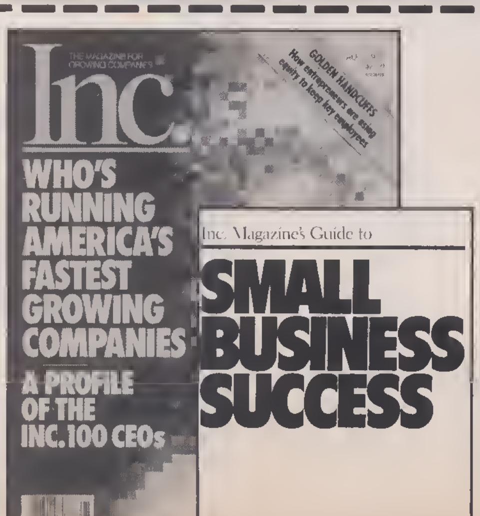

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PERSPECTIVES

Information gateways make on-line databases easier to use

Electronic databases have become a popular way for personal computer users to obtain information rapidly about a variety of subjects, from organic chemicals to stocks to wine vintages. Approximately 3000 such databases are available to the public. But retrieving the information has sometimes been a chore, as users have wrestled with arduous sign-on procedures and arcane command languages that differ from one database to the next.

Several companies have now come to the rescue with easy-to-use software packages that streamline database access. With these information gateways, or front ends, users enter search requests via menus and English-like commands. The gateway decides which database is most likely to contain the desired information, translates the user's query into the language of the target database, dials it up, retrieves the information, and presents it to the user. By shielding the user from nasty query languages, front ends open the most technical databases to novices, and can even save professional researchers time.

Some firms offer information gateways as software products that can be purchased and installed on the user's personal computer. Other companies offer them only as a dial-up service for which a fee is charged. Some gateway services base their charges on that of the target database; others charge a flat fee for a search request that can be substantially less than that of the databases.

The front-end companies are aiming their products and services at personal computer users. About 5% of personal computer owners already tap into online information sources, according to Robert Bartolotta, an analyst with Link Resources (New York), and that percentage is expected to triple over the next few years.

The most advanced front end is a service called EasyNet, developed by Telebase Systems (Narberth, Pa.). Anyone with a PC or a terminal and a modem can call EasyNet's toll-free number, enter a credit card number, and take a crack at any of 630 databases; the user can specify a particular database or let the system choose one according to the questions asked. There are no passwords or registration procedures, and no familiarity with database searches is required. "No one should care how a database works," says senior vice-president Marvin Weinberger, "any more than they care how their phone works."

EasyNet costs $1 to sign on plus $8 per question, regardless of search time and database. If the system can't provide an answer, there is no charge (although EasyNet must still pay the database vendor). In contrast, information services that are accessed without a gateway usually charge by the hour, whether the search is fruitful or not. Such fees vary from $8.40 per hour for The Source (McLean, Va.), a consumer-oriented service, to $125 per hour for Hazardline, a database offered by BRS (Latham, N.Y.) that covers 3000 toxic substances. Many services also charge one-time registration and minimum monthly fees, while EasyNet does not.

Inaugurated last February, EasyNet picked up 5000 customers in its first five months. Telebase is now talking to several corporations about customizing the service to meet their particular needs. For example, PC users at pharmaceutical manufacturer SmithKline Beckman (Philadelphia) will be able to use Easynet to access company databases in addition to the commercial information services.

EasyNet's future looks promising, particularly in view of Western Union's plan to market the gateway to the 120,000 users of its electronic mail service. A rival gateway did not fare so well, though. Business Computer Network (BCN) offered a more limited service. BCN connected the user to any of 24 information services, each offering a number of databases; unlike EasyNet, however, the BCN system had no query language of its own. Once logged into a database, the user formulated requests in its native query language. BCN's sophisticated customers preferred it that way, according to marketing director Arnold Schuchter. He says that translated queries such as those made by EasyNet yield only "an approximation" of the response a user would get from a direct query. Apparently, the database search market did not agree: BCN closed down its service last fall.

Heavy users of data banks can reduce on-line charges by outfitting their PCs with a special gateway package. One such package is available for $495 from Menlo (Santa Clara, Cal.). Called

JOE CIARDIELLO

Pro-Search, it automatically dials and signs on to any database, keeping track of search charges by database, subject, and client—a useful feature for professional researchers. In addition, it translates the user's search requests into a format understood by two popular vendors: Dialog Information Services (Palo Alto, Cal.) and BRS. Another PC-based package, called PC/Net-Link, is available for $550 from Informatics General (Woodland Hills, Cal.). A drawback to the PC software approach is that database vendors occasionally modify access or search procedures, rendering the front end obsolete until the user obtains a new version.

All this activity hasn't been lost on database vendors, many of which are moving to provide front ends to their own systems. BRS recently added an EasyNet-like option called "Brkthru," making flat-rate, menu-driven searches available on almost all of its 80 databases. SDC (Santa Monica, Cal.) has dropped minimum monthly charges on its database, and offers customers a $299 PC-based front-end program that also works with other major vendors' databases.

With front ends, the only inconvenience remaining is that of having to use a telephone—and one database vendor has at least partially licked that problem. Isys (Acton, Mass.) offers PC-resident versions of several financial databases. Users can forget about access codes and charges—that is, until they have to call Isys for an update. There's always something. □

—David Freedman

Flying disk holds distance record

Hurl a flat disk in the air and almost invariably it will roll to one side, crashing to the ground after a fairly short journey. Alan Adler, a lecturer in engineering at Stanford, spent six years developing an aerodynamically advanced flying disk that would go farther than anything had been thrown before. The culmination of his work, the Aerobie, recently set a new world record of 1125 feet—about two football fields farther than the longest Frisbee throw.

The problem with an ordinary disk is that the center of lift is not located at the same spot as the center of gravity; the lift force is usually farther forward. This displacement between the upward and downward forces generates a turning force (or torque). Obeying the same physical principle that makes a gyroscope work, the disk responds by turning sideways, at right angles to the direction of the torque. This rolling motion hampers attempts at long, straight flight. Adler's challenge was thus to find a way to move the center of lift in a spinning disk to the disk's center of gravity to eliminate this destabilizing torque.

Lift is generated whenever air is forced to flow faster over the top of an object than beneath it. A standard airplane wing (airfoil) accomplishes this effect with a curved top surface; air moves faster over the top because it has a longer distance to travel. As speed over the top of the wing increases, pressure drops and a suction—lift—is created. Lift increases with air speed and the angle at which the wing meets the onrushing air (the angle of attack).

An airfoil's center of lift is usually located about one-fourth of the distance between its leading and trailing edges. With a properly designed airplane, the lift created by the wing can be harnessed to produce level flight. Frisbees achieve relatively level flight because the thick rim creates enough turbulence in the air to move the center of lift to an area close to the center of gravity. "The price of that thickness, however, is a great deal of drag," Adler explains; thus, a Frisbee will succumb to gravity rather quickly (the record toss is 456 feet).

After experimenting with different thin disks, Adler began to focus on a ring shape, because the center of lift was easier to control. A ring moving through the air consists of two airfoils—the forward half and the rear half. The problem is that as the forward half of the ring develops lift, the air behind it is deflected downward. The rear half of the ring, flying in this "downwash," develops less lift than does the forward half. As a result, the center of lift shifts forward and torque is produced. To achieve straight flight, Adler had to eliminate this torque by designing a shape that caused the forward and rear halves of the ring to develop equal lift.

Adler's first breakthrough came with the "Skyro," marketed several years ago by Parker Brothers. The Skyro had an angled airfoil that decreased the angle of attack (and thus the lift) of the forward half of the ring while increasing the angle of attack (and lift) of the rear half. However, the Skyro generated different angles of downwash at different speeds and thus achieved the equilibrium needed for level flight at only one speed; it rolled to the left at lower speeds and to the right at higher speeds. Despite its limited stability, the toy had a narrow profile that generated relatively little drag, and in 1980 a Skyro was thrown 857 feet to set a Guinness World Record.

Inventor Alan Adler flings two Aerobies. A computer simulation led him to the aerodynamic design that has made the toy the world's farthest-thrown object.

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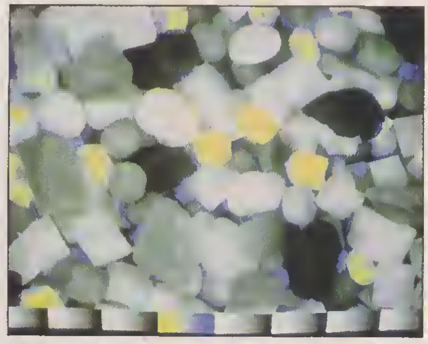
Adler continued to work on the problem. Last winter, he devised a computer simulation that indicated a formula for attaining perfect balance at all speeds. The trick, Adler calculated, was to adjust the "lift slope" of the ring's two airfoils. Lift slope is the rate at which the lift force increases as a function of attack angle; stable flight would occur, it appeared, if the lift slope were 50% higher at the rear half of the ring than at the front half.

Of course, as the ring spins, the forward half becomes the rear half, and vice versa. Thus, Adler explains, "I needed an airfoil section with 50% greater lift slope when flying forward—the orientation of the rear half—than when flying backward."

After several setbacks, Adler finally settled on and patented a design that included a small lip, or spoiler, on the ring's outer edge. When the spoiler encounters the air, it creates enough turbulence to separate the airflow and reduce front-end lift. "In effect," Adler says, "the spoiler bursts the bubble of suction." With front-end lift slope reduced, fore and aft distribution of lift stays relatively constant, and the ring achieves equilibrium at a wide range of speeds.

Adler's Palo Alto company, Superflight, began commercial production in December 1984, and expects to have sold about half a million Aerobies in 1985. To stir up interest in the $8.95 toy, the company is offering a $1000 reward to the first person who flings an Aerobie 1200 feet. □ ***—David C. Allon***



Kernels of corn show up yellow in a computer pseudocolor image of a vegetable mix that also contains lima beans, green peas, carrots, red peppers, and olives.

Computer eyes turn to food

Already on its way to becoming a well-established technology in factories, machine vision is moving on to new challenges. So far, two-thirds of these systems—which combine TV cameras with computers to recognize patterns and detail—are used on production lines, particularly in the automotive and electronics industries. But machine vision "transcends manufacturing," says Nello Zuech, a consultant at Vision Systems International (Yardley, Pa.).

The most immediate new opportunities, says Zuech, will be in agriculture and food processing. Machines that see could assist in everything from picking crops to assuring quality of the final packaged product. The latter is especially important in the food industry, where inadequately inspected products could lead to injury and lawsuits, observes George R. Gagliardi, an analyst at Arthur D. Little (Cambridge, Mass.). But the conservative food industry—which is more likely to invest in marketing than R&D—has been slow to see the advantages machine vision could bring. "There is a lot of inertia," says Gagliardi.

There are also technical challenges. In inspecting manufactured items, a vision system's computer often makes a simple accept-or-reject decision by comparing the part on the production line against a standard-part image stored in memory. But these convenient parameters apply to man-made objects, and cannot be transferred readily to the varying conditions of agriculture.

One key advance in machine vision that has improved its prospects for use in food processing is the ability to detect shades of gray rather than simple black and white. Gray scale is a prerequisite for inspecting objects for color, which is an important indicator of food quality. It is not necessary for the machines to work with full color processing; instead, appropriate color filters can be placed over monochrome cameras.

Another important step toward agricultural applications is the reduced requirement for lighting. Older machine-vision systems often needed carefully controlled lasers or stroboscopic lamps to highlight areas of interest on inspected parts, but improvements in computer signal processing now make it possible for the equipment to work under ordinary illumination—such as the sunlight bathing a field of crops.

The benefits could be enormous. In current machine harvesting, harvesters pick the entire crop at one pass. A more complex machine with a built-in vision system could select just the ripe items by their size and color, says Roger Brook of Michigan State University's agricultural engineering department. Unripe fruit would remain on the plants for later harvesting.

Researchers at the University of Florida (Gainesville) are working on a vision system to pick citrus fruit in just this way. Citrus crops are comparatively easy to pick automatically, says agricultural engineering professor Roy Harrell, because the fruit ripens with good color uniformity and stays ripe for a long time. With a yellow filter over the camera, the fruit that is ready to pick shows up as white, while leaves and next year's small green fruit appear dark.

Picking strawberries could be similarly improved, says Brook of Michigan State. But problems remain for automated picking where color has less meaning. Ripe apples, for example, may be wholly red, wholly green, or any combination of those colors.

Machine vision's role need not stop after the food is harvested. Citrus growers, for example, could use a vision system to grade their fruit, sending perfect-looking oranges to produce markets and relegating the blotchier specimens to the juice works. Such discrimination requires a computer to compare gray levels among neighboring pixels (picture elements) in order to assess color uniformity. The computer power needed for such a task has only recently become cost-effective, says Gagliardi.

Potential applications exist farther down the food-processing chain as well. Arthur D. Little is studying a system that would distinguish the ingredients in frozen mixed vegetables. A color filter is put in front of the camera, and the six vegetables in the mixture are

identified by how dark they appear. For example, with a yellow filter, the corn will be very light and the peas dark, with the carrots somewhere in between. The computer then checks that the mixture conforms to the specified proportions. □

—Hugh Aldersey-Williams

Reinventing the coal-burning train

Three small U.S. companies hope to resurrect coal-burning locomotives from the history books by adding a few new technological twists to the old train designs. Their goal: a locomotive that is more efficient, more reliable, and cleaner than the smoke-belching engines of yesteryear.

The incentives are strong: Coal can be produced domestically for half the price of the diesel fuel used to power today's electric trains. U.S. trains burn $4 billion of diesel oil a year, so a return to coal could dramatically reduce railroad operating costs and diminish U.S. dependence on imported oil. These savings could make railroads more competitive with trucks, which have been losing their advantage because of increased urban highway congestion.

The new locomotives would make extensive use of microprocessors and other advanced electronics. But what really sets them apart from previous coal-burning engines is a new firebox made possible by contemporary knowledge about how coal burns.

In a conventional steam train, a shallow bed of coal burns at a relatively low temperature. Such a bed is prone to cool spots, however; also, the gases produced from the burning coal flow too fast to permit full combustion. Indeed, the plume of black smoke spewing from 19th-century trains dramatically illustrates the engine's incomplete combustion, with unburned gases lost to the atmosphere. The proposed trains would burn coal far more completely, discharging a minimum of combustible hydrocarbons and very little dust or tar.

The three firms' designs differ in the details of how the coal is burned and how its energy is transferred to the driving wheels. American Coal Enterprises (ACE—Lebanon, N.J.) is working on a wholly new steam train that would equal or exceed a diesel-electric's starting power while exceeding its high-speed horsepower. The latter capability is becoming increasingly important as railroads operate higher-speed freight trains. Brobeck (Berkeley, Cal.) and National Steam Propulsion (NSP—Woburn, Mass.) focus on modifying diesel-electric trains for coal, changing as few components as possible.

Because steam trains last operated in an era without electronic sensors and sophisticated thermodynamic analysis, a necessary first step in the development of new designs was the collection of accurate baseline data. ACE's solution was to use company president Ross Roland's own steam train; last winter, the train pounded over a stretch of track in West Virginia pulling coal-filled hopper cars. Also in tow were passenger cars filled with technicians and their electronic monitoring devices.

ACE engineers won't talk about what this trip revealed, but a train operated by South African Railways (SAR) may provide a clue. Because South Africa has no oil but plenty of coal, SAR retained its steam locomotives long after most railroads converted to diesel-electric or all-electric (with overhead wire). One of SAR's steam locomotives was recently converted to run at higher efficiency by David Wardale, an English designer who has worked with ACE. Modest improvements to the firebox, valves, and steam passages boosted the locomotive's horsepower from 3000 to over 5000 while reducing by one-third its consumption of water and coal. Another benefit was a cleaner exhaust, with virtually no cinders or unburned gases in the form of black smoke.

The heart of the ACE concept is a "gas producer" firebox, which goes far beyond the modifications of the SAR design. Coal will be burned in a deep bed; incoming air mixed with jets of steam will be injected directly into the burning mass of coal. This process will result in nearly complete combustion of low-sulfur coal. Cyclone burners and precipitators will then clean the remaining exhaust gas of particulates to a very high degree.

Flames from the burning coal will flow through firetubes within a boiler. Steam from the boiler will be piped to four cylinders located on the side of the engine as in a conventional steam locomotive. Pistons within the cylinders will transfer the steam's energy to side rods connected to eight large driving wheels. The power-transfer system has been carefully balanced to avoid damaging the track, a key drawback of earlier direct-drive steam engines. Condensers will continually recycle the steam so the train won't have to stop repeatedly to replenish the feedwater.

Brobeck has attempted to meld the best of the diesel-electric locomotive to the low cost of coal. Coal would be burned in bottle-like chambers; introducing steam into the burning mass would cause a reaction between the carbon, air, and water to yield a gas containing approximately 80% of the coal's chemical energy. This gas—primarily carbon monoxide—would be cleaned of tar, dust, and sulfur (in the form of hydrogen sulfide) and then piped to a conventional, spark-ignited internal combustion engine. The engine, in turn, would drive an alternator to power axle-mounted electric motors to propel the train.

In National Steam Propulsion's design, coal would be burned at a very high temperature in a deep "fluidized bed" containing limestone. Steam generated in pipes passing through the mass of burning coal would drive a reciprocating 12-cylinder engine built upon the basic block of an existing diesel. A big advantage of NSP's approach is that more than 90% of the sulfur dioxide generated by the fire would be removed by the limestone, allowing the engine to use cheap, high-sulfur coal. Moreover, the limestone's reaction with sulfur dioxide yields calcium sulfate, or ordinary gypsum, which can be sold off to defray operating expenses.

While the ACE, Brobeck, and National Steam designs may all prove to be technically viable, they must contend in a low-volume, capital-intensive industry that can support only a few builders. And the three small firms are likely to clash with General Motors and General Electric—giants that dominate the current locomotive market and that are working on coal-burning engines as well. □

—Christopher C. Swan

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1	11	21	31	41	51
2	12	22	32	42	52
3	13	23	33	43	53
4	14	24	34	44	54
5	15	25	35	45	55
6	16	26	36	46	56
7	17	27	37	47	57
8	18	28	38	48	58
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References

The Seybold Report on Professional Computing. Seybold Publications, Box 644, Media, PA 19063, (215) 565-2480. Newsletter.

PC Magazine. Ziff-Davis Publishing Co., One Park Ave., New York, NY 10016. Current info on the IBM PC, PC/AT, and clones, including the most comprehensive comparative articles on both soft-

Franklin Meyer. *High Technology,* Sept./Oct. 1981.

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"In the wings: self-repairing jets." Jeff Richmond. *High Technology,* July 1985.

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TECHSTARTS

Ansa Software:

BREAKING INTO THE PC SOFTWARE MARKET

Conventional wisdom says it should be well-nigh impossible to launch a new general-purpose software package for personal computers during the current industrywide slowdown, but Ansa Software is doing just that with Paradox, its database management system. To help Paradox beat the odds, the company patterned the program's user interface after the format of widely used Lotus 1-2-3 and also included a mechanism for exchanging files with 1-2-3 and many other popular programs. But to succeed, Ansa will have to sell to first-time buyers of database management systems as well as win converts from the leading packages—Ashton-Tate's dBase II and Software Publishing's PFS:file—in a market where customers are notoriously loyal.

Financing: Venture capital financing from Sevin Rosen Management and Kleiner Perkins Caufield & Byers.

Management: Founders Richard Schwartz and Robert Shostak, both holding the title of VP of software development, were computer scientists at SRI International. Chairman Benjamin Rosen and president Steven Dow are partners in Sevin Rosen Management. Rosen is also chairman of Compaq Computer.

Location: 1301 Shoreway Rd., Belmont, CA 94022, (415) 595-4469.

Founded: August 1984.

Synektron:

MAKING MOTORS THAT THINK FOR THEMSELVES

One of the biggest problems for motors, solenoids, and other motion-control devices has been keeping speed or pressure constant despite electrical fluctuations and mechanical disturbances. Synektron's solution is to add microprocessors that can react to troublesome fluctuations as well as make motion devices more versatile. "Smart" motors and actuators can run variable-speed air conditioners and other home appliances, automotive equipment, robots, and machine tools, as well as computer peripherals such as disk drives (the company's original application). Synektron has formed a joint venture in Hong Kong with Japan's Kyocera Corp. to market such products in the Far East. But it will eventually have to contend with heavyweight competition—at home and abroad—from established motor makers like General Electric, which has similar products under development.

Financing: $13 million in venture capital from investors including Hillman Co., Xerox, Kyocera International, Portland General Electric (a utility company), and Cable Howse and Cozadd.

Management: Gerald Gould, president and CEO, was president and CEO of GE of Japan, which manages General Electric's operations in Japan, Taiwan, and Korea. Craig L. Berkman, chairman and founder, was president of Cardiac Resuscitator and chairman of Catheter Technology. Raymond deWeese, cofounder and a director, was president of Catheter Technology and, previously, of Cascade Video.

Location: 12000 SW Garden Pl., Portland, OR 97223, (503) 684-3090.

Founded: August 1981.

President Gerald Gould (left) and chairman and founder Craig Beckman of Synektron, a manufacturer of "smart" motors and motion-control devices.

XTAL:

HELPING FACTORIES GO PAPERLESS

Most of today's automated factories still consist of "islands of automation," containing machines and computer systems that can't share data. For example, drawings created on a computer-aided design (CAD) system often have to be recoded and the results punched into paper tape in order to run many numerically controlled machine tools. XTAL's Factorynet system automatically converts CAD data into instructions that machine tools can understand, transfers them without paper tape, and in many cases can also electronically link automated inspection systems. The company also intends to add links to robots and MRP systems. Although similar networks are under development by factory automation vendors like General Electric and major users like General Motors, the competition hasn't yet heated up. XTAL is targeting large manufacturing companies; Honeywell, Whirlpool, and Baxter-Travenol Laboratories are already customers.

Financing: An initial public stock offering in May 1984 of 805,000 shares at $3.25 per share generated net proceeds of $2.19 million. A June 1985 private offering of stock at $5.50 per share raised another $1 million.

Management: Kendell E. Johnson, president and CEO, was a founder and VP of marketing and sales for computer graphics company Digigraphic Systems and was previously VP of logistics for Control Data Corp. John S. Titus, VP of R&D, was a founder of CAD/CAM company CAMAX Systems, a division of National Computer Systems, and previously designed a CAD/CAM system used by jewelry manufacturer Josten.

Location: 12217 Nicollet Ave., Minneapolis, MN 55337, (612) 894-9010.

Founded: July 1983.

INTERACTIVE VIDEODISC GETS DOWN TO BUSINESS

Education and employee training promise steady growth

After several years of disappointing sales to home consumers, laser videodiscs have found a more profitable niche in the business market, where they are being used predominantly for education and training. Interactive video systems combine still-frame and moving video images, sound, and computer-generated overlays of text and graphics. When prompted by a user through input devices such as touch screens and mouse pointers, they become patient teachers or sales reps with an encyclopedic command of a product line.

Interactive education does not come cheap, however. Hardware may cost at least $10,000 per system, and customized courseware development can run $100,000 and up per disc, depending on the length and complexity of the program. But businesses have been attracted to the potential savings that accrue from travel costs, lost job time, and instructors' salaries foregone when students can take videodisc courses where they work. Some corporate users maintain that a variety of job skills can actually be taught more effectively by videodisc systems than by traditional methods.

Markets are now emerging for other interactive video applications as well. In point-of-purchase retail advertising, a system can display the product and current information on performance, pricing, and delivery terms. Real estate companies, art galleries, and science museums can use videodiscs to store and display information such as houses for sale or slides of exhibits; videodiscs are also used to document maintenance information about industrial and military equipment.

These applications are expected to drive the market for videodisc systems and courseware from an estimated $116 million this year to $1.1 billion by 1990, according to *Videodisc Monitor* (Arlington, Va.). Several major consumer electronic and computer companies compete in this market, including DEC, Hitachi, Pioneer, Philips, and Sony. In addition, some smaller firms have gained a foothold with videodisc programs, course-authoring software, and refurbished IBM-style PCs or add-on boards that convert PCs and disc players into fully functional systems. Among these companies are two public corporations: Perceptronics (Woodland Hills, Cal.) and Wicat Systems (Orem, Utah).

Perceptronics (OTC: PERC) produces videodisc-based training and simulation programs. Its major customer is the U.S. government; the Army alone has purchased $1 million worth of the MK series programs for training tank gunners, while the Defense Advanced Research Projects Agency has awarded $5 million to the firm for work on simulators for the M-1 tank and the Bradley Fighting Vehicle. Perceptronics is trying to broaden its market base in the private sector through its Action Code family of industry-specific courseware packages, which the National Education Corp. recently agreed to market. For the home market, Perceptronics offers a system that simulates travel while a user rides an exercise bicycle.

Revenues in fiscal 1985 were $15.5 million, versus $7.4 million in 1984. Net income in 1985 reached $346,000 with earnings of 26¢ per share, up from 1984's loss of $1.1 million.

A Wicat interactive videodisc system is used by TWA for pilot training. Cockpit controls for the DC-9 aircraft are simulated by courseware on the monitor and may be adjusted with a touchpad.

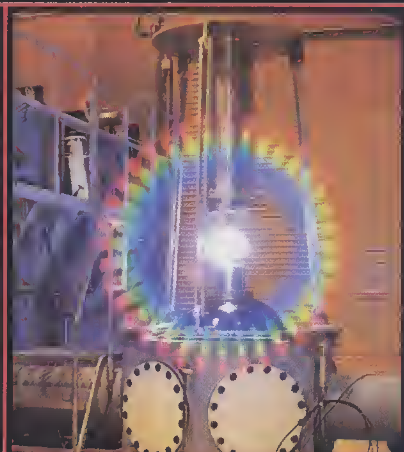
Wicat Systems (OTC: WCAT) manufactures a broad line of microcomputers and educational software for children. The firm offers interactive videodisc hardware and courseware, as well as course-authoring software. The latter provides a template with which a company can put together its own videodisc programs for much less expense than customized courses. These products were recently incorporated into a training division, from which Wicat expects to earn 20% of this year's revenues. Targeting its efforts at the airlines and communications industries, Wicat's strategy is to install prototype systems to demonstrate the effectiveness of videodisc-based training. Customers could then create their own educational applications with the company's authoring software, which would enhance hardware sales.

Positioned initially as a microcomputer manufacturer, Wicat sustained serious losses when IBM released its PC. But the first two quarters of fiscal 1986 were profitable for the company, thanks to a product line reoriented to education and training, and a cut in R&D and administrative expenses. In 1985, Wicat had a net loss of $6.1 million, based on sales of $29.1 million, for a 30¢ loss per share. This was an improvement over 1984's loss of $13.4 million on sales of $23.2 million, and a 70¢ loss per share.

Investors should also keep an eye on some private companies. **Visage** (Natick, Mass.) provides videodisc systems, add-on equipment for IBM PCs and ATs, and an extensive array of software development products. These include graphics development tools, high-level languages, systems software, and a computer-based training language. **Digital Techniques** (Burlington, Mass.) produces a modular, touch-screen system featuring high-resolution color graphics as well as interactive video capabilities. This product costs less than comparable systems from large vendors such as DEC. □

by Michael D. Millikin

Michael D. Millikin is associate editor of The Seybold Report on Office Systems *(Boston).*



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